PART I

ANTARCTIC SITE INVENTORY

DESIGN, PURPOSE AND GOALS

The major impetus for the Antarctic Site Inventory project is the 1991 Environmental Protocol to the Antarctic Treaty, which entered into force, as a matter of international law, in 1994. There had been no previous effort to catalogue the biological and physical resources of Antarctic Peninsula zodiac landing sites. Thus, an overarching goal is to establish baselines of site-descriptive information and biological data, which will enable environmental changes to be detected and potential causes for such changes to be examined.

Following a year of examining methodologies and logistics, the Antarctic Site Inventory began fieldwork in November 1994; specifically, the project intended to:

- determine whether opportunistic visits can be used to effectively and economically detect possible visitor-caused changes in the physical features, flora, and fauna of sites in the Antarctic Peninsula being visited repeatedly by ship-based tourists;
- begin collecting baseline information necessary to detect possible changes in the physical and biological variables being monitored; and
- determine how best to minimize or avoid possible environmental impacts of tourism and non-governmental activities in the Antarctic Peninsula area.

Theoretically, these data and information will: allow direct and cumulative impacts to be detected; ensure that the best scientific data and descriptive information are available should Antarctic Treaty Parties determine that site management is necessary and appropriate; contribute to a better understanding of biological processes in the entire Antarctic Peninsula region; and suggest additional biological research that might be accomplished with respect to penguins and shags.

From the Inventory's inception, it was intended that collected data and information be made publicly and routinely available, thus assisting visitors in determining how best to minimize, or potentially avoid, environmental impacts.

Any potential, management efforts by Antarctic Treaty countries inevitably require a consideration of whether or not any detected impacts, direct or cumulative, are naturally occurring, perhaps caused by tourism or other human activities, or result from other causes (Benninghoff and Bonner, 1985; Abbott and Benninghoff, 1990).

RESULTS

Through February 2003, the Inventory has made 503 visits/surveys throughout the Antarctic Peninsula, involving 82 different locations (see Table 1). There have been repetitive visits to all of the visitor sites that are most heavily visited by expedition tourists, and to all sites which exhibit the most species diversity and which are most prone to potential environmental disturbance from human visitors (Naveen, 1997a; Naveen, et. al: 2000, 2001).

Table 1: Cumulative list of visited by Antarctic Site Inventory researchers, by Antarctic Site Inventory subarea, 1994-2003

		Acronym	Latitude / Longitude
	SOUTH ORKNEY ISLANDS SUBAREA (SO)		
1	Amphibolite Point	AMPH	60˚ 41’ S 45˚ 21’ W
2	Gibbon Bay	GIBB	60˚ 39’ S 45˚ 11’ W
3	Orcadas Station Vicinity	ORCA	60˚ 46’ S 44˚ 40’ W
	ELEPHANT ISLAND SUBAREA (EI)		
4	Point Lookout	LOOK	61˚ 17’ S 55˚ 13’ W
5	Point Wild	WILD	61˚ 06’ S 54˚ 52’ W
	NORTHEAST PENINSULA SUBAREA (NE)		
6	Bald Head	BALD	63˚ 38’S 57˚ 36’ W
7	Brown Bluff	BROW	63˚ 32’ S 56˚ 55’ W
8	Camp Hill *	HILL	63˚ 41’ S 57˚ 52’ W

		Acronym	Latitude / Longitude
9	Cape Burd	BURD	63˚ 39’ S 57˚ 09’ W
10	Crystal Hill	CRYS	63˚ 39’ S 57˚ 54’ W
11	d’Urville Monument	DURV	63˚ 31’ S 58˚ 11’ W
12	Devil Island	DEVI	63˚ 48’ S 57˚ 17’ W
13	Eagle Island	EAGL	63˚ 40’ S 57˚ 29’ W
14	Eden Rocks *	EDEN	63˚ 29’ S 55˚ 40’ W
15	False Head Point, Vega Island	FALS	63˚ 55’ S 57˚ 20’ W
16	Heroína Island	HERO	63˚ 24’ S 54˚ 36’ W
17	Hope Bay	HOPE	63˚ 23’ S 57˚ 00’ W
18	Jade Point *	JADE	63˚ 36’ S 57˚ 35’ W
19	Jonassen Island *	JONA	63˚ 33’ S 56˚ 40’ W
20	Madder Cliffs, Joinville Is.	MADD	63˚ 18’ S 56˚ 29’ W
21	Marambio Station Vicinity	MARA	64˚ 13’ S 56˚ 38’ W
22	Paulet Island	PAUL	63˚ 35’ S 55˚ 27’ W
23	Penguin Point, Seymour Island	PEPO	64˚ 19’ S 56˚ 43’ W
24	Persson Island	PERS	64˚ 13’ S 58˚ 24’ W
25	Point Obelisk, James Ross Island	OBEL	64˚ 08’ S 58˚ 27’ W
26	Rum Cove, James Ross Island	RUMC	64˚ 06’ S 58˚ 25’ W
27	Snow Hill Island	SNOW	64˚ 28’ S 57˚ 12’ W
28	Tay Head, Joinville Island	TAYH	63˚ 21’ S 55˚ 34’ W
29	View Point	VIEW	63˚ 33’ S 57˚ 22’ W
	SOUTH SHETLAND ISLANDS SUBAREA (SH)		
30	Aitcho Islands	AITC	62˚ 24’ S 59˚ 47’ W
31	Arctowski Station Vicinity, King George Island	ARCT	62˚ 15’ S 58˚ 51’ W
32	Baily Head/Rancho Point, Deception Island	BAIL	62˚ 58’ S 60˚ 30’ W
33	Ferraz Station Vicinity, King George Island	FERR	62˚ 10’ S 58˚ 48’ W
34	Fort Point, Greenwich Is.	FORT	62˚ 43’ S 59˚ 34’ W
35	Half Moon Island	HALF	62˚ 36’ S 59˚ 55’ W
36	Hannah Point, Livingston Island	HANN	62˚ 39’ S 60˚ 37’ W
37	Jubany Station, King George Island	JUBA	62˚ 14’ S 58˚ 38’ W
38	Mitchell Cove, Robert Island	MITC	62˚ 24’ S 59˚ 40’ W
39	Pendulum Cove, Deception Island	PEND	62˚ 56’ S 60˚ 36’ W
40	Penguin Island	PENG	62˚ 06’ S 57˚ 54’ W
41	Robert Point, Robert Island	ROBE	62˚ 28’ S 59˚ 23’ W
42	Telefon Bay, Deception Island	TELE	62˚ 56’ S 60˚ 40’ W
43	Turret Point, King George Island	TURR	62˚ 05’ S 57˚ 55’ W
44	Vapour Col, Deception Island	VAPO	62˚ 59’ S 60˚ 44’ W
45	Whaler’s Bay, King George Island	WHAL	62˚ 59’ S 60˚ 34’ W
46	Yankee Harbor, Livingston Island	YANK	62˚ 32’ S 59˚ 47’ W
	NORTHWEST PENINSULA SUBAREA (NW)		
47	Almirante Brown Station Vicinity, Paradise Bay	ALMI	64˚ 53’ S 62˚ 52’ W
48	Astrolabe Island	ASTR	63˚ 17’ S 58˚ 40’ W
49	Bernardo O’Higgins Station	BERN	63˚ 19’ S 57˚ 54’ W
50	Cuverville Island	CUVE	64˚ 41’ S 62˚ 38’ W
51	Danco Island	DANC	64˚ 44’ S 62˚ 37’ W
52	Dorian Bay/Damoy Point	DORI	64˚ 49’ S 63˚ 30’ W
53	Foyn Harbor, Enterprise Is.	FOYN	64˚ 33’ S 62˚ 01’ W
54	Georges Point, Rongé Island	RONG	64˚ 40’ S 62˚ 40’ W
55	Gourdin Is.	GOUR	63˚ 12’ S 57˚ 18’ W
56	Gouvernøren Harbor	GOUV	64˚ 32’ S 62˚ 00’ W
57	Hydrurga Rocks	HYDR	64˚ 08’ S 61˚ 37’ W
58	Jougla Point, Port Lockroy, Wiencke Island	LOCK	64˚ 49’ S 63˚ 30’ W
59	Lecointe Island *	LECO	64˚ 16’ S 62˚ 03’ W
60	Melchior Islands	MELC	64˚ 19’ S 62˚ 57’ W
61	Mikklesen Harbor, Trinity Island	MIKK	63˚ 54’ S 60˚ 47’ W

		Acronym	Latitude / Longitude
62	Neko Harbor, Andvord Bay	NEKO	64˚ 50’ S 62˚ 33’ W
63	Orne Islands	ORNE	64˚ 40’ S 62˚ 40’ W
64	Portal Point	POPT	64˚ 30’ S 61˚ 46’ W
65	Priest Island (Goetschy Island), Peltier Channel *	PRIE	64˚ 52’ S 63˚ 31’ W
66	Py Point	PYPT	64˚ 53’ S 63˚ 37’ W
67	Siffrey Point	SIFF	63˚ 13’ S 57˚ 13’ W
68	Sprightly Islands Vicinity	SPRI	64˚ 18’ S 61˚ 03’ W
69	Waterboat Point, Paradise Bay	WATE	64˚ 49’ S 62˚ 51’ W
	SOUTHWEST PENINSULA SUBAREA (SW)		
70	Blaicklock Island	BLAI	67˚ 33’ S 67˚ 04’ W
71	Booth Island	BOOT	65˚ 05’ S 64˚ 00’ W
72	Detaille Island	DETA	66˚ 52’ S 66˚ 48’ W
73	Fish Islands	FISH	66˚ 02’ S 65˚ 25’ W
74	McCall Point	MCAL	67˚ 02’ S 66˚ 38’ W
75	Petermann Island	PETE	65˚ 10’ S 64˚ 10’ W
76	Pléneau Island	PLEN	65˚ 06’ S 64˚ 04’ W
77	Pourquoi-pas Island *	POUR	67˚ 43’ S 67˚ 44’ W
78	Prospect Point	PROS	66˚ 0’1 S 65˚ 21’ W
79	Shumskiy Cove	SHUM	67˚ 04’ S 67˚ 21’ W
80	Stonington Island	STON	68˚ 11’ S 67˚ 00’ W
81	Vernadsky Station	VERN	65˚ 15’ S 64˚ 16’ W
82	Yalour Islands	YALO	65˚ 14’ S 64˚ 10’ W

* = Site visited by Antarctic Site Inventory researchers, but not specifically listed in compilations of site visit data for 1989-2003, prepared by the U. S. National Science Foundation Office Of Polar Programs (NSF/OPP), based on site visit data submitted by tour operators.

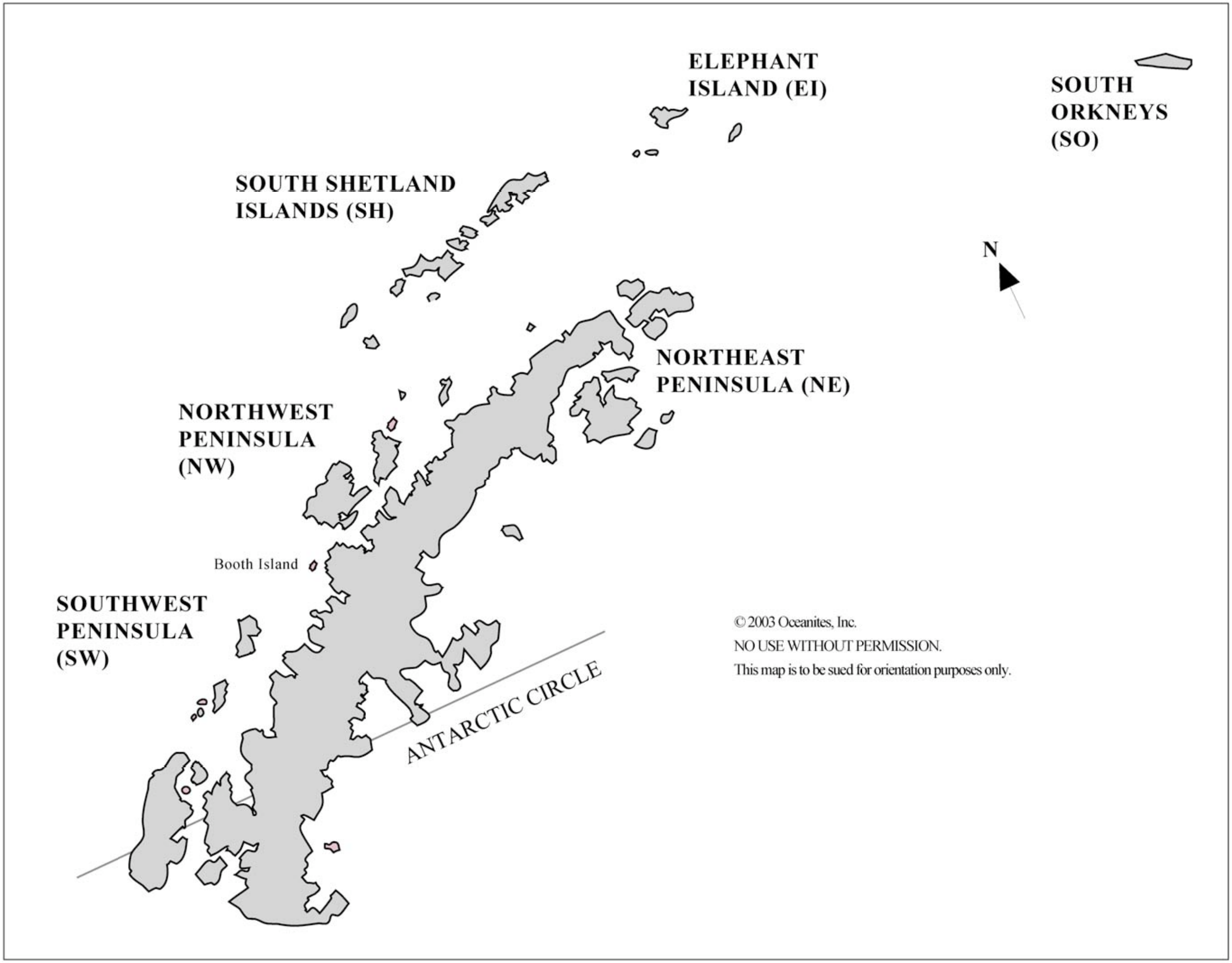
The Inventory has demonstrated that opportunistic, well-timed visits by trained researchers have proved an resourceful, cost-effective means of characterizing sites and for collecting relevant biological data (Naveen, 1997a; Naveen, et. al: 2000, 2001). This has been accomplished by relying upon expedition tour vessels and the United Kingdom ice patrol vessel *HMS Endurance* for logistics support.

SUBAREAS

The Inventory divides the Antarctic Peninsula into six subareas:

- South Orkney Islands, including Laurie, Coronation, and Signy Islands (SO);
- Elephant Island and nearby islands (EI);
- Northeast Antarctic Peninsula/northwestern Weddell Sea (NE), from Cape Dubouzet (63˚16’S 64˚00’W) to James Ross Island;
- South Shetland Islands, including Deception, Low, and Smith Islands (SH);
- Northwest Antarctic Peninsula (NW), from Cape Dubouzet (63˚16’S 64˚00’W) to north end of the Lemaire Channel; and
- Southwest Antarctic Peninsula (SW), from the north end of the Lemaire Channel to the northern part of Marguerite Bay (68˚18’S 67˚11’W).

The following seven maps depict the Antarctic Site Inventory study area and these six subareas:



ELEPHANT
ISLAND (EI)
SOUTH
ORKNEYS
(SO)
SOUTH SHETLAND
ISLANDS (SH)
N
NORTHEAST
PENINSULA (NE)
NORTHWEST
PENINSULA
(NW)
Booth Island
SOUTHWEST
PENINSULA
(SW)
ANTARCTIC CIRCLE
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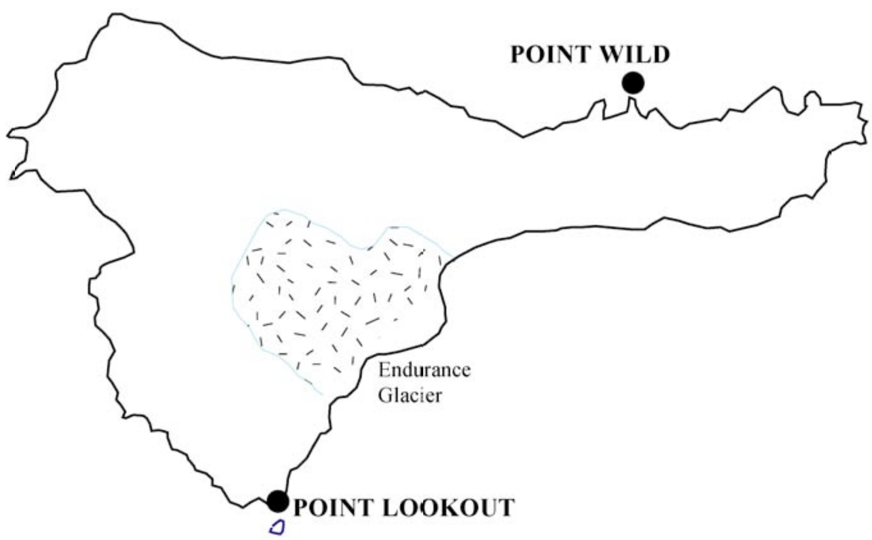
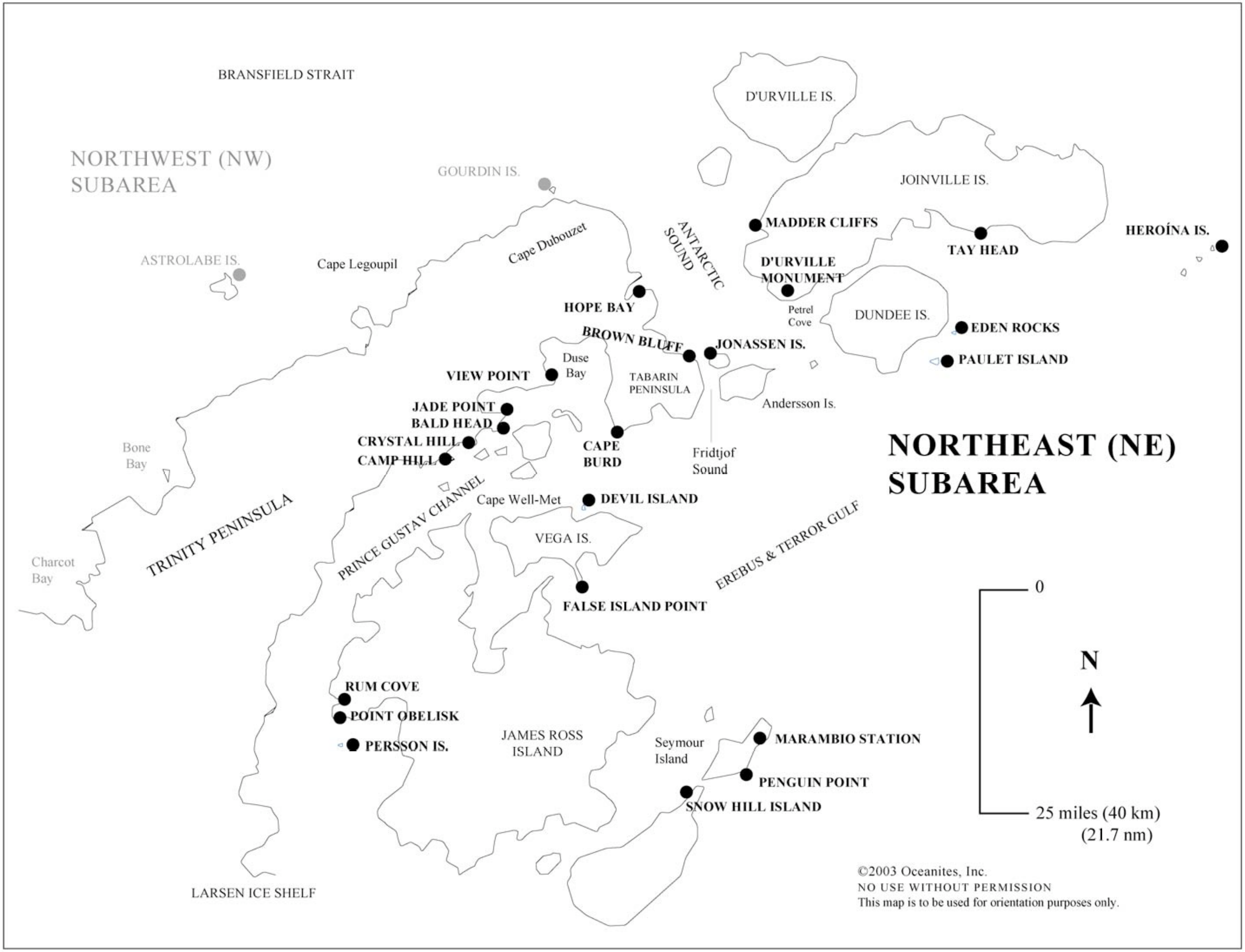
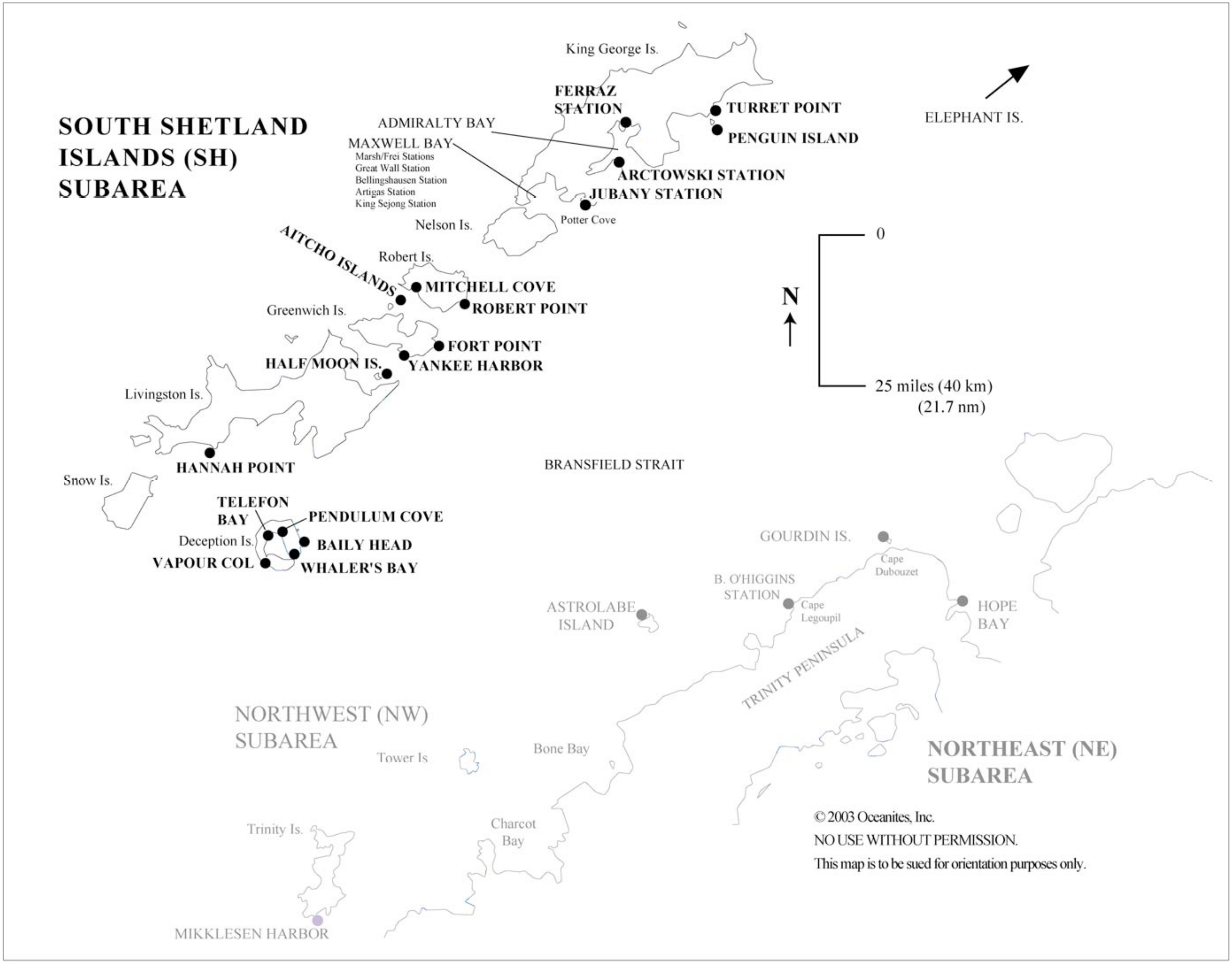
SOUTH ORKNEY ISLANDS

ELEPHANT ISLAND

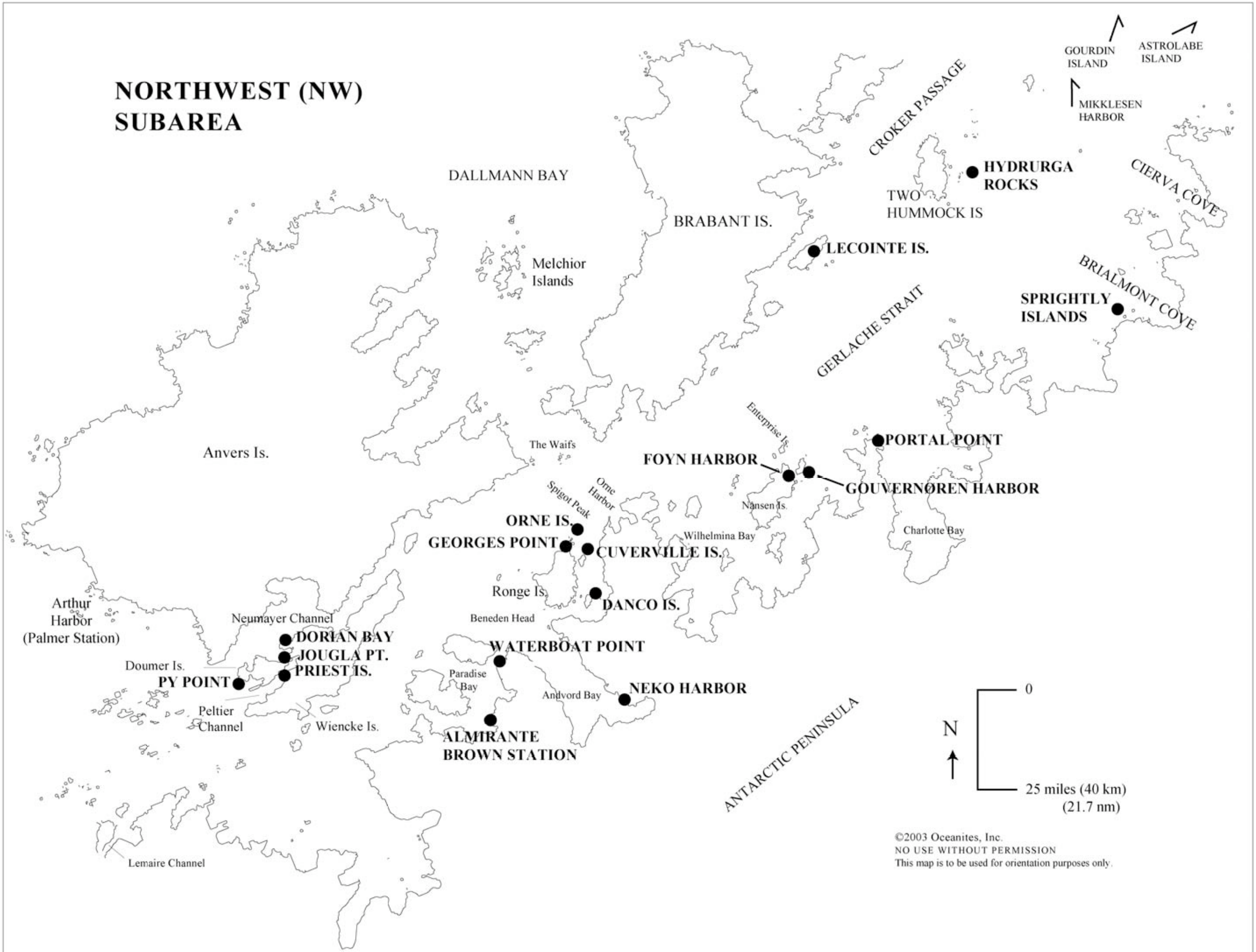


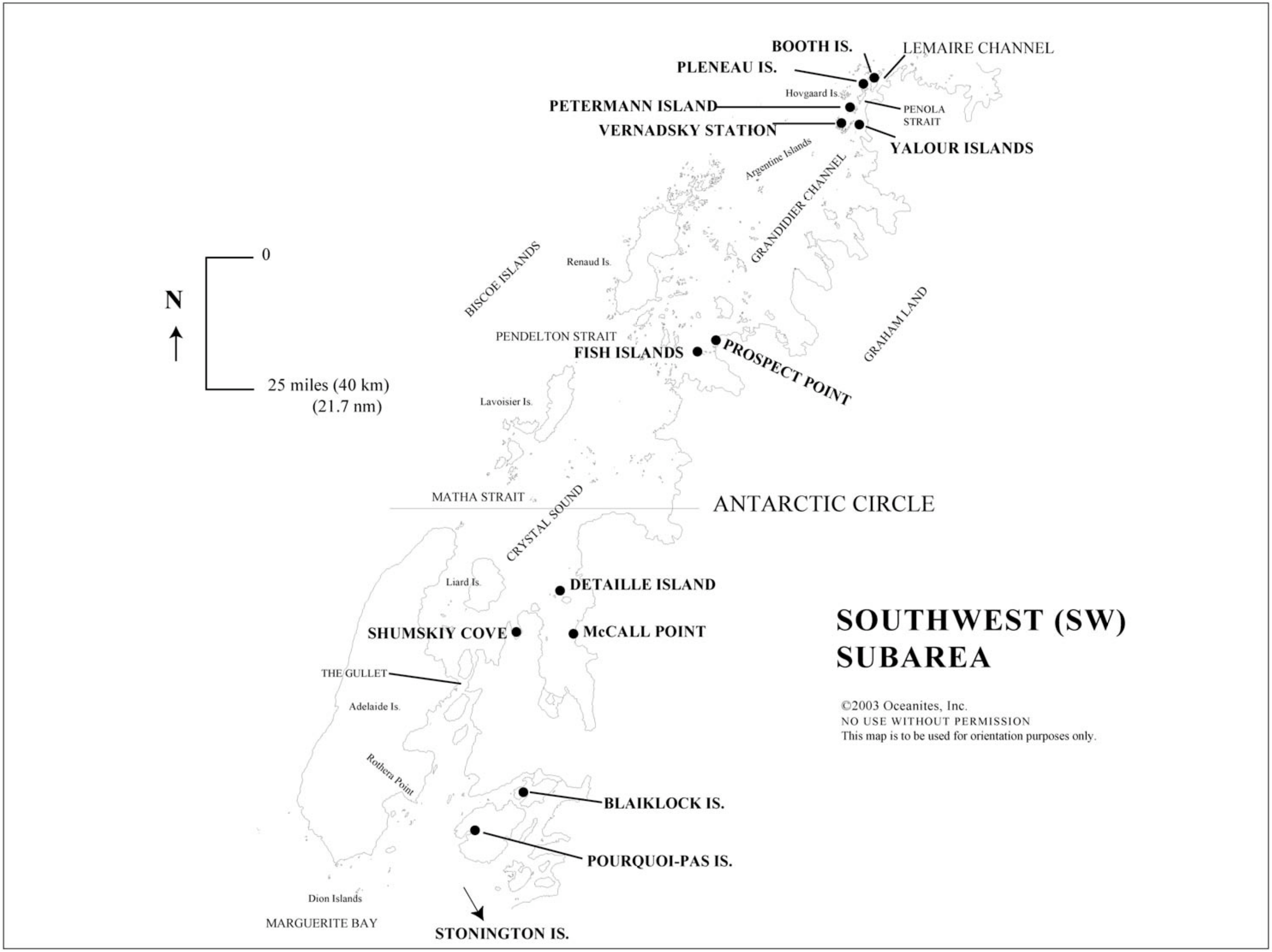


NORTHEAST (NE) SUBAREA


SOUTH SHETLAND
ISLANDS (SH)
SUBAREA
King George Is.
FERRAZ
STATION
TURRET POINT
PENGUIN ISLAND
ELEPHANT IS.
ADMIRALTY BAY
MAXWELL BAY
Marsh/Frei Stations
Great Wall Station
Bellingshausen Station
Artigas Station
King Sejong Station
ARCTOWSKI STATION
JUBANY STATION
Potter Cove
Nelson Is.
Robert Is.
AITCHO ISLANDS
MITCHELL COVE
ROBERT POINT
Greenwich Is.
FORT POINT
HALF MOON IS.
YANKEE HARBOR
Livingston Is.
HANNAH POINT
Snow Is.
BRANSFIELD STRAIT
TELEFON
BAY
PENDULUM COVE
Deception Is.
BAILY HEAD
VAPOUR COL
WHALER'S BAY
N
0
25 miles (40 km)
(21.7 nm)
GOURDIN IS.
Cape
Dubouzet
B. O'HIGGINS
STATION
Cape
Legoupil
HOPE
BAY
ASTROLABE
ISLAND
TRINITY PENINSULA
NORTHWEST (NW)
SUBAREA
Tower Is
Bone Bay
NORTHEAST (NE)
SUBAREA
Trinity Is.
Charcot
Bay
MIKKLESEN HARBOR

NORTHWEST (NW) SUBAREA




BOOTH IS.
LEMAIRE CHANNEL
PLENEAU IS.
Hovgaard Is.
PETERMANN ISLAND
PENOLA
STRAIT
VERNADSKY STATION
YALOUR ISLANDS
Argentine Islands
GRANDIDIER CHANNEL
0
N
25 miles (40 km)
(21.7 nm)
BISCOE ISLANDS
Renaud Is.
GRAHAM LAND
PENDELTON STRAIT
FISH ISLANDS
PROSPECT POINT
Lavoisier Is.
MATHA STRAIT
CRYSTAL SOUND
ANTARCTIC CIRCLE
Liard Is.
DETAILLE ISLAND
SHUMSKIY COVE
McCALL POINT
THE GULLET
Adelaide Is.
Rothera Point
BLAIKLOCK IS.
POURQUOI-PAS IS.
Dion Islands
MARGUERITE BAY
STONINGTON IS.
SOUTHWEST (SW)
SUBAREA
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DATA CATEGORIES

The Inventory's methodology (described in Naveen: 1996, 1997a) involves the collection of three categories of data and information.

The first category, *Basic Site Information*, includes descriptions of key physical and topographical characteristics; latitude and longitude; distribution of flora, seal haul-out and wallow locations, and discrete groups of breeding penguins and flying birds.

At each site, to evaluate species diversity and site sensitivities, the Inventory collects data regarding the presence or absence of nesting species of penguins and flying birds, wallows of southern elephant seals, and large patches or beds of lichens and mosses at all sites visited. These data are used to rank sites as to their species diversity, based on the number of faunal species and major floral groups recorded. Using these presence/absence data as a base, sites also are ranked as to their potential sensitivity to disruption by visitors, depending on: the number of penguin and seabird species whose nests visitors may access easily, whether or not visitors may access southern elephant seal wallows easily, and whether or not visitors may access easily and possibly trample large patches or beds of lichens and mosses.

Census data collection proceeds according to Standard Methods used in the CCAMLR Ecosystem Monitoring Program, particularly Standard Method A3A (v4), which relates to *breeding population size* and Standard Method A6 (v5), Procedure A, which relates to *breeding success*. With respect to blue-eyed shags, data collection follows similar methodologies because, at present, there are no applicable CEMP methods specifically pertaining to blue-eyed shags. The aim is to determine interannual trends in the size of breeding populations. A decline in a breeding population would be one indication that a penguin population at a particular site is being impacted.

This data collection method specifically pertains only to ground counts of nests in entire colonies. The mandated procedure is to select one or more colonies that are discrete, which separately can be counted as a whole unit, and which will not be affected by other studies or on-site human activities. The census colonies must be well defined and distributed in various parts of the study area. It is important that the same colonies be counted annually and that the counts are made one week after peak egg-laying. The colonies must be clearly marked and mapped. Once established, the same colonies will be used to assess chick numbers under CCAMLR Standard Method A6 (v5), Procedure A, described below. Instructions given to Antarctic site Inventory researchers may be found in Appendix 2.

The nest census procedure requires that three separate counts should be made of each of the selected colonies on the same day; if one of the three counts differs more than 10% from the others, a fourth count should be made on the same day as the other three counts.[1] The total number of birds engaged in breeding activity can be influenced by: cohort size at fledging and rate of recruitment of each cohort to the breeding population; food supply during pre-laying and incubation periods; ages of individual birds (and consequently the age structure of colony); previous breeding experience of the individuals; the length of mate-bond; presence of mate; size and location of colony; and ice conditions prior to colony occupation.

CCAMLR Standard Method A6 (v5), Procedure A will be utilized to estimate *breeding success*. The aim is to assess productivity by providing an index of relative change in the number of chicks produced one year to the next. A decline in the number of chicks produced per occupied nest would be one indication that a penguin population at a particular site is being impacted.

As with the censusing of occupied nests, Standard Method A6 (v5), Procedure A requires the selection of one or more colonies that are discrete, which separately can be counted as a whole unit, and which will not be affected by other studies or on-site human activities. The census colonies must be well defined, distributed in various parts of the study area, and clearly marked and mapped. It is important that the same colonies be counted annually. The colonies should be the same as those used to assess breeding population size CCAMLR Standard Method A3A (v4), described above.

The chick census procedure requires that three separate counts should be made of each of the selected colonies on the same day, during the peak of chick-créching. The CCAMLR chick censusing methodology states that if one

[1] In practice, the Antarctic Site Inventory has tightened the CCAMLR nest censusing procedure by requiring three counts within 8%, to ensure that Type I and Type II statistical errors are completely avoided. The justification for this change is explained in Appendix 2.

of the three counts differs more than 10% from the others, a fourth count should be made on the same day as the other three counts.[2]

The methodology cautions researchers to walk slowly in performing their work to avoid disruptions that might cause the breakage of eggs or predation by skuas. The methodology provides that results should be analyzed to produce mean numbers of chicks at each colony or breeding area for the number of counts employed (minimum three). These data can be used as an index of breeding success directly by comparing counts for specific colonies or groups of colonies, or indirectly by expressing the results as the mean number of chicks per adult over a group of colonies, yielding an attendant variance. It is important that the colonies or breeding areas, and dates of counts are standardized.

Breeding success will be indicative of many factors, notably adult condition and colony size, food availability, predator pressure, ice conditions and other environmental features. The success of breeding expressed both as total number of chicks raised and number of chicks raised per adult will have important implications for future population size. Season-to-season variation in breeding success can be considerable.

The second category of data and information, *Variable Site Information and Data*, includes weather and other environmental conditions (sea ice extent, cloud cover, snow cover, temperature, wind direction and speed), biological variables (number of occupied nests, number of chicks per occupied nest, ages of chicks), and the nature and extent of any observed visitor impacts (footprints or paths, cigarette butts, film canisters, and litter). With respect to penguins and flying birds, the focus is collecting data on breeding population size (nest counts) and breeding productivity (number of chicks per active nest), which are the appropriate biological parameters for detecting direct and cumulative impacts on these populations (Scientific Committee for the Conservation of Antarctic Marine Living Resources, 2001).

The third category of data and information, *Maps and Photodocumentation*, is an effort to portray major features of each site, particularly the locations of colonies and assemblages of resident fauna and flora. Orientation maps are crafted to assist Inventory researchers in their regular, season-to-season censusing. Oblique aerial photodocumentation has transpired via a cooperative arrangement among Oceanites, the UK Foreign and Commonwealth Office, and the Royal Navy ice patrol ship *HMS Endurance*. The oblique aerial photodocumentation from HMS Endurance, conducted by helicopter, conforms fully to guidelines established by the UK Foreign and Commonwealth Office to avoid harmful interference with concentrations of Antarctic wildlife.

Inventory researchers use 35mm and digital cameras to photodocument — within a season from season-to-season, and from the same vantage points — flora (lichen, mosses, and grass), penguin and seabird colonies, seal haul-out sites, and other features. Over time, repetitive photodocumentation from the same vantage point potentially may record on-site changes. In the 2001-02 field season, the Inventory experimented with a kite-flown digital camera in order to obtain images of inaccessible penguin nesting groups.

Original site sketches and maps are digitized and archived for safe-keeping. Oblique aerial photodocumentation is used to upgrade site sketches and maps. Photographic slides are similarly stored. All film canisters are marked in the field according to a designation system that enables original slides to be catalogued by field season, roll number, and frame-number, and which insures the correct identification of all photographs of a particular site. Digital photographs, catalogued in a similar fashion, are stored on CD-R disks.

INDICATOR SPECIES

The Inventory considers the following fauna and flora, found variously throughout the Peninsula, to be potential indicators of environmental change:

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[2] As noted in footnote 1, the Antarctic Site Inventory has tightened the CCAMLR censusing procedure by requiring three counts within 8%, to ensure that Type I and Type II statistical errors are completely avoided. See Appendix 2.

Table 2: Indicator species

Seals	
Southern elephant seal	*Mirounga leonina*
Penguins	
Adélie penguin	*Pygoscelis adeliae*
Chinstrap penguin	*Pygoscelis antarctica*
Gentoo penguin	*Pygoscelis papua*
Macaroni penguin	*Eudyptes chrysolophus*
Flying birds	
Southern giant petrel	*Macronectes giganteus*
Antarctic fulmar	*Fulmarus glaciodes*
Pintado petrel	*Daption capense*
Snow petrel	*Pagodroma nivea*
Blue-eyed shag	*Phalacrocorax atriceps*
Snowy sheathbill	*Chionis alba*
Skua, spp.	*Catharacta lonnbergi*
	Catharacta maccormicki
Kelp gull	*Larus dominicanus*
Antarctic tern	*Sterna vittata*
Flora	
Antarctic hair grass	*Deschampsia antarctica*
Antarctic pearlwort	*Colobanthus quitensis*
Moss, spp.	*Bryum*, spp.
	Brachythecium, spp.
	Drepanocladus, spp.
	Polytrichum, spp.
Crustose lichens, spp., fruticose and foliose lichens, spp.,	*Xanthoria*, spp.
	Caloplaca, spp.
	Verrucaria, spp.
	Haematomma, spp.
	Usnea, spp.
	Umbilicaria, spp.
	Ramalina, spp.
	Physcia, spp.
	Prasiola crispa (and its lichenized form, *Mastodia tesselata*)
Snow Algae	

CENSUS STRATEGIES

Taking cues from the literature (Trivelpiece, 1991; Emslie, 1997; Croxall & Kirkwood, 1979; Woehler, 1993; Woehler & Croxall, 1996), the Inventory has focused on censusing four penguin species (gentoo, Adélie, chinstrap, and macaroni) and four species of flying birds (blue-eyed shags, southern giant petrels, kelp gulls, and skuas, spp.). Scree-nesting seabirds (storm-petrels, spp.; Antarctic fulmars; Antarctic petrels; snow petrels) were too difficult to census regularly in the short times expected for Inventory visits because these species' nests are generally inaccessible and, at times, difficult to discover. Antarctic terns presented a different problem: nesting territories were readily ascertained, but censusing is difficult because of this species' extraordinary skittishness, and the camouflage of its eggs and young. As a consequence, Inventory researchers note Antarctic tern breeding grounds in field data and orientation maps, but do not expend time trying to achieve censuses.

Regarding penguins, differences in breeding biology led to different Inventory census strategies (Trivelpiece, 1991; Williams, 1995; Emslie, 1997). Chinstraps and Adélies are site-specific animals, which do not tend to abandon regular nest sites and rookeries if there is a breeding failure in a single season. Gentoos, by contrast, are not as site-tenacious and gentoo-pairs regularly change nesting locations if there are disturbances. The implications for Inventory-like projects are that: gentoo censuses only may have long-term relevance if all gentoos at a particular visitor sites are counted, including all subgroups and small colonies of gentoos found at that site; and censuses of chinstraps and Adélies may have long-term relevance even if all chinstraps or Adélies at a particular location cannot be counted.

With respect to chinstraps and Adélies, Inventory personnel generally selected census colonies of fewer than 300 active nests. Colonies with greater than 300 active nests (e.g. at Baily Head and Hannah Point) consistently proved to be more difficult to census. With respect to macaroni penguins, Hannah Point is the only Peninsula visitor site where this species is regularly encountered, and the small numbers of nests, adults, and chicks are readily tracked. Emslie (1997) notes that while some studies have shown that the cumulative effect of repeated visits to penguin colonies over many years has caused no significant decline in colony size or reproductive performance, and that penguins tend to become habituated to the presence of humans and human disturbances near their nest sites, other studies indicate potential effects on recruitment by new breeding pairs to heavily-visited colonies, which may cause a population decline over time, especially to small colonies. At this stage, it is unclear whether the Hannah Point macaroni population is growing, declining, or remaining steady.

In the first edition of the *Compendium*, regarding the relevance of Inventory census data for reproductive comparisons, Oceanites recommended a need for correlation studies to determine how close opportunistic Inventory nest and chick counts are to the peaks of egg-laying and chick-créching, respectively (Scientific Committee for the Conservation of Antarctic Marine Living Resources, 1992). Alternatively, in this second edition, Oceanites recommends long-term monitoring of a few select sites that are heavily visited, diverse in species composition, and sensitive to potential environmental impacts; at select sites where this long-term monitoring is realized, data will be collected according to CCAMLR Standard Methods and, thus, be fully comparable with data collected elsewhere in the Antarctic.

Preaching extreme care in the use of Inventory-collected data does not and should not suggest a lack of usefulness. For example, note that historical compilations of minimum penguin breeding populations (Croxall & Kirkwood, 1979; Woehler, 1993; Woehler & Croxall, 1996) reflect nest counts obtained at various times and in varying fashions. No filter insures that these data reflect nest counts achieved at the peak of egg-laying. The only filter applied to these data relates to the exactitude of the counts themselves (i.e. whether they represent actual nest counts or estimates with varying degrees of accuracy). These compilations are valuable sources of information about penguin distribution, often reflect more detailed work being done at various locations, and if repeated may suggest trends. In other words, “one-off” counts that are carefully accomplished during each breeding season are useful and should be repeated as often as possible.

The Inventory has achieved flying bird censuses (blue-eyed shags, southern giant petrels, kelp gulls, and skuas, spp.), but not in as much detail as with similar censuses of penguin colonies. Shag nests, adults, and chicks are regularly censused at eight sites. Kelp gull and skua nests at various locations were readily noted and marked both in Inventory data sheets and on Inventory orientation maps. Both species readily take flight on close approaches and, thus, Inventory personnel give them a wide berth, confining notes and data to the location of nests, numbers of adults tending nests, and numbers of chicks observed at a distance. Censuses of the southern giant petrels were consistently difficult to accomplish, being perhaps the most skittish of these flying birds, nesting in scrapes on the ground and easily agitated. The standard Inventory *modus operandii* is to walk the far perimeter of giant petrel nesting areas to reduce potential disturbances to an absolute minimum.

With respect to non-avian fauna, Inventory personnel regularly census seals on the landing beaches of Peninsula visitor sites, and track numbers of southern elephant seals in easily accessed wallows.

With respect to Antarctic Peninsula flora communities, Inventory researchers record the presence of lichens, mosses, *Deschampsia*, and *Colobanthus*, and there is an effort to photodocument as much of this vegetation as possible. Specific identifications are coordinated with British Antarctic Survey personnel. Some locations have readily accessed and often extensive moss beds (the Aitcho Islands, Penguin Island, the upper slopes of Cuverville Island, the vicinity of the Ferraz Station, Pléneau Island). Other sites present easily accessed *Usnea* lichens and *Deschampsia* (inland of the beach walk at Arctowski Station, Whalers Bay).

To avoid duplication of effort, the principal investigator of the Inventory coordinates with other national Antarctic programs and their scientists, and with representatives of the Scientific Committee on Antarctic Research (SCAR) and its specialist groups, regarding ongoing and previous scientific effort that relates directly to sites being surveyed. At sites where on-site flora have been photographed, identification of such flora is made in coordination with the British Antarctic Survey.

No Inventory effort takes place at sites where national Antarctic programs are operating research stations. However, five of these sites — Ferraz Station (SH), Arctowski Station (SH), Half Moon Island (SH), Bernardo O'Higgins Station (NW), and Vernadsky Station (SW) — are included in the compendium for reference, because they are relatively, frequently visited by tourists. The recently restored (and frequently visited) hut at Goudier Island is referenced in the site description of Jougla Point, Port Lockroy (NW).

REGULAR INVENTORY CENSUSES

As of the close of the 2002-03 field season, the Antarctic Site Inventory regularly censuses 17 Antarctic Peninsula sites:

BROW	Brown Bluff	NE
PAUL	Paulet Is.	NE
ALMI	Almirante Brown STN vicinity	NW
HYDR	Hydrurga Rocks	NW
LOCK	Jougla Point, Port Lockroy	NW
NEKO	Neko Harbor	NW
ORNE	Orne Is.	NW
RONG	Georges Pt., Rongé Is.	NW
WATE	Waterboat Point	NW
AITC	Aitcho Is.	SH
BAIL	Baily Head, Deception Is.	SH
HANN	Hannah Point	SH
WHAL	Whaler's Bay	SH
PENG	Penguin Is.	SH
YANK	Yankee Harbor	SH
PETE	Petermann Is.	SW
PLEN	Pléneau Is.	SW

Specific chinstrap penguin groups are regularly censused at eight sites:

HYDR	Hydrurga Rocks	NW
ORNE	Orne Is.	NW
RONG	Georges Pt., Rongé Is.	NW
WATE	Waterboat Point	NW
AITC	Aitcho Is.	SH
BAIL	Baily Head, Deception Is.	SH
HANN	Hannah Point	SH
PENG	Penguin Is.	SH

Specific Adélie penguin groups are regularly censused at three sites:

PAUL	Paulet Is.	NE
PENG	Penguin Is.	SH
PETE	Petermann Is.	SW

Regular, site-wide gentoo penguin censuses take place at nine sites:

BROW	Brown Bluff	NE
LOCK	Jougla Point, Port Lockroy	NW
NEKO	Neko Harbor	NW
RONG	Georges Pt., Rongé Is.	NW
WATE	Waterboat Point	NW
HANN	Hannah Point	SH
YANK	Yankee Harbor	SH
PETE	Petermann Is.	SW
PLEN	Pléneau Is.	SW

Macaroni penguins are regularly censused at one site:

HANN	Hannah Point	SH

Blue-eyed shags are regularly censused at eight sites:

PAUL	Paulet Is.	NE
ALMI	Almirante Brown STN Vic.	NW
HYDR	Hydrurga Rocks	NW
LOCK	Jougla Point, Port Lockroy	NW
ORNE	Orne Is.	NW
HANN	Hannah Point	SH
PETE	Petermann Is.	SW
PLEN	Pléneau Is.	SW

Southern giant petrels are regularly censused at three sites:

AITC	Aitcho Is.	SH
HANN	Hannah Point	SH
PENG	Penguin Is.	SH

Kelp gulls are regularly censused at one site:

WHAL	Whaler’s Bay	SH

Nest and chick census data are collected according to the methods described in the CEMP Standard Methods for Monitoring Studies (Scientific Committee for the Conservation of Antarctic Marine Living Resources, 1992) and other pertinent authorities, in particular, Croxall & Kirkwood (1979, and Woehler (1993).

CONTROL AND EXPERIMENTAL COLONIES

At each site, Inventory researchers attempt to select and establish prospective control (seldom disturbed) colonies and experimental (frequently disturbed) colonies of penguins and flying birds to census. The intent is to regularly repeat censuses both near and far from landing beaches where visitors access a particular location, to allow comparisons, over time, between areas where there is comparatively much and little human activity.

In some instances, these discrete groups of penguins and flying birds are marked by wooden stakes to insure that they can be relocated and censused from the same perspective during future visits. The stakes bear numbered tags that are referenced on the project’s orientation maps.

To date, the inventory has established control colonies at these seven visitor sites:

PAUL	Paulet Is.	NE
ORNE	Orne Is.	NW
AITC	Aitcho Is.	SH
BAIL	Baily Head, Deception Is.	SH
HANN	Hannah Point	SH
PENG	Penguin Is.	SH
PETE	Petermann Is.	SW

LOGISTICS

In terms of logistics, the Inventory attempts to reach as many visitor sites as possible each austral spring and summer season, especially within the appropriate time frames for collecting nest and chick census data.

Expedition ships are selected carefully, particularly those with: the longest Peninsula itineraries whose Initial Environmental Evaluations have been reviewed by national authorities; and whose operations and expedition personnel enable Inventory researchers to reach the most heavily visited sites and to collect data at key census times (the peak of egg-laying for nest counts and the peak of chick-crèching for chick counts). Site visits and aerial photodocumentation also have been undertaken in cooperation with the British Royal Navy ice patrol vessel *HMS Endurance*. (Naveen: 1996, 1997a, 1999)

The ships utilized as platforms are noted both in site descriptions and the chronological list of Inventory site visits/censuses in Appendix 1.

LONG-TERM MONITORING AT KEY SITES

Beginning in November 2003, the Antarctic Site Inventory will begin a long-term monitoring and assessment study at Petermann Island. This effort involves a three-person team of researchers being on-site during the respective peaks of penguin egg-laying (for nest counts) and penguin chick-créching (for chick counts), and will not depend on opportunistic logistics from carefully selected expedition ships. As a result, these long-term data sets will enable more accurate estimates of breeding population size and breeding success of Adélie penguin (*Pygoscelis adeliae*), gentoo penguin (*Pygoscelis papua*), and blue-eyed shag (*Phalacrocorax atriceps*), and allow direct and cumulative impacts at these sites to be detected precisely. Further, such data, will ensure that the best scientific data and descriptive information are available should Antarctic Treaty Parties determine that site management is necessary and appropriate in the future and contribute to a better understanding of biological processes in the entire Antarctic Peninsula region,

PUBLICATIONS, REPORTS, AND PAPERS

Biological data and site descriptions collected by the Inventory have been published and routinely made available in peer-reviewed papers, government reports, and popular publications (Naveen: 1996, 1997a, 1997b; Naveen, et. al, 2000, 2001). The most recent of these peer-reviewed papers are:

- *Prevalence of Leucism in Pygoscelid Penguins of the Antarctic Peninsula*, *Waterbirds* 23 (2): 283-285 (Forrest, S. and Naveen, R., 2000).
- *Censuses of penguin, blue-eyed shag, and southern giant petrel populations in the Antarctic Peninsula region*, 1994-2000, *Polar Record* 36 (199): 323-334 (Naveen, R., Forrest, S.C., Dagit, R.G., Blight, L.K., Trivelpiece, W.Z., and Trivelpiece, S.G., 2000).
- *Zodiac landings by tourist ships in the Antarctic Peninsula region*, 1989-99, *Polar Record* 37 (201): 121-132 (Naveen, R., Forrest, S.C., Dagit, R.G., Blight, L.K., Trivelpiece, W.Z., and Trivelpiece, S.G., 2001).

Summaries of Inventory data and results have been submitted routinely as information papers to annual consultative meetings of the Antarctic Treaty parties:

- Naveen, R., 1995a. Pilot Study To Assess The Potential Utility Of An Antarctic Site Inventory, Information Paper (IP 47) submitted by the United States to the XIXth Antarctic Treaty Consultative Meeting in Seoul, Republic of Korea.
- Naveen, R., 1995b. Implementation of Recommendation XVIII-1. United States Information Paper for the XIXth Antarctic Treaty Consultative Meeting in Seoul, Republic of Korea.
- Naveen, R., 1996a. Antarctic Site Inventory: Summary During Two Seasons Of Field Work — 1994 to 1996, Information Paper (IP 102) submitted by the United States to the XXth Antarctic Treaty Consultative Meeting in Utrecht, The Netherlands.
- Naveen, R., 1996b. Photodocumentation Of Survey Sites: Report Of A Cooperative International Program During the 1995-96 Austral Summer, Information Paper (IP 100) submitted by the United States and the United Kingdom to the XXth Antarctic Treaty Consultative Meeting in Utrecht, The Netherlands.
- Naveen, R., 1997c. Antarctic Site Inventory: Summary Of Progress — 1994 to 1996, Information Paper (IP 114) submitted by the United States and the United Kingdom to the XXIst Antarctic Treaty Consultative Meeting in Christchurch, New Zealand.
- Naveen, R., 1998. Antarctic Site Inventory: Update On Results Through Completion of the 1997-98 Field Season, Information Paper (IP 27) submitted by the United States, the United Kingdom, and Germany to the XXIInd Antarctic Treaty Consultative Meeting in Tromsø, Norway.

- Naveen, R., 1999a. Antarctic Site Inventory: Update On Results Following Completion of the 1998-99 Field Season, Information Paper (IP 32) submitted by the United States, the United Kingdom, and Germany to the XXIIIrd Antarctic Treaty Consultative Meeting in Lima, Peru.
- Naveen, R., 2002. Antarctic Site Inventory: 1994-2002, Information Paper (IP 25) submitted by the United Kingdom and the United States to the XXVth Antarctic Treaty Consultative Meeting in Warsaw, Poland.
- Naveen, R., 2003. Antarctic Site Inventory: 1994-2003, Information Paper (IP 53) submitted by the United Kingdom and the United States to the XXVIth Antarctic Treaty Consultative Meeting in Madrid, Spain.

DETAILS REGARDING OCEANITES AND THE ANTARCTIC SITE INVENTORY

The Antarctic Site Inventory project is managed and operated by Oceanites, Inc., a non-profit science and education foundation based in Chevy Chase, Maryland USA. Ron Naveen is the founder and chief executive officer of Oceanites, Inc., and the principal investigator of the Antarctic Site Inventory project. At present, Inventory field work is permitted under U.S. Antarctic Conservation Act Permit No. 2000-12, issued to Oceanites, Inc. for the period September 1, 1999 to August 31, 2004. In addition, the US Environmental Protection Agency has determined that Oceanites has met the criteria in 40 US Code of Federal Regulations §8.4(e) for a multi-year Initial Environmental Evaluation, through the 2006-2007 Antarctic field season.

Further information about Oceanites and the Antarctic Site Inventory may be obtained via email (oceanites.mail@verizon.net) and regular mail (P.O. Box 15259, Chevy Chase, MD 20825 USA).

The raw materials for this second edition of the *Compendium* are the data sheets, slide photographs, and sketch maps compiled by Antarctic Site Inventory researchers from November 1994 to February 2003. As noted, these data, documentary photographs, and maps are stored by Oceanites.

Appendix 1: Chronological list of site visits by Antarctic Site Inventory researchers, 1994-2003

	Site	Subarea	Date	Researcher(s)	Platform
1994-1995 Field Season					
1	ARCT	SH	November 26, 1994	RN ST	from COPA
2	ARCT	SH	November 27, 1994	RN	from COPA
3	ARCT	SH	December 4, 1994	RN	from COPA
4	HALF	SH	December 6, 1994	RN BH	Alla Tarasova
5	PETE	SW	December 7, 1994	RN	Alla Tarasova
6	WATE	NW	December 7, 1994	RN RD RP BH	Alla Tarasova
7	CUVE	NW	December 8, 1994	RN	Alla Tarasova
8	LOCK	NW	December 8, 1994	RN BH	Alla Tarasova
9	BAIL	SH	December 9, 1994	RN BH	Alla Tarasova
10	HANN	SH	December 9, 1994	RN BH	Alla Tarasova
11	WHAL	SH	December 9, 1994	RN BH	Alla Tarasova
12	ALMI	NW	December 10, 1994	RN BH	Livonia
13	CUVE	NW	December 10, 1994	RN	Livonia
14	LOCK	NW	December 11, 1994	RN BH	Livonia
15	PETE	SW	December 11, 1994	RN BH	Livonia
16	PLEN	SW	December 11, 1994	RN	Livonia
17	WHAL	SH	December 12, 1994	RN BH	Livonia
18	YANK	SH	December 12, 1994	RN	Livonia
19	BAIL	SH	December 14, 1994	RN BH	Livonia
20	YANK	SH	December 14, 1994	RN BH ST	Explorer
21	ALMI	NW	December 15, 1994	RN	Explorer
22	DORI	NW	December 15, 1994	RN BH ST	Explorer
23	LOCK	NW	December 15, 1994	RN BH ST	Explorer
24	PETE	SW	December 15, 1994	RN BH ST	Explorer
25	ORNE	NW	December 16, 1994	RN BH	Explorer
26	POPT	NW	December 16, 1994	RN SF	Explorer
27	ARCT	SH	January 12, 1995	RN RD	Livonia
28	PENG	SH	January 12, 1995	RN RD	Livonia
29	YANK	SH	January 12, 1995	RN RD	Livonia
30	ORNE	NW	January 13, 1995	RN RD	Livonia
31	BAIL	SH	January 14, 1995	RN RD	Livonia
32	PAUL	NE	January 22, 1995	RN	Explorer
33	SNOW	NE	January 22, 1995	RN	Explorer
34	HANN	SH	January 23, 1995	RN RD	Explorer
35	WHAL	SH	January 23, 1995	RN	Explorer
36	ALMI	NW	January 24, 1995	RN	Explorer
37	CUVE	NW	January 24, 1995	RN	Explorer
38	ORNE	NW	January 24, 1995	RN RD	Explorer
39	FISH	SW	January 25, 1995	RN RD	Explorer
40	PROS	SW	January 25, 1995	RN RD	Explorer
41	DORI	NW	January 26, 1995	RN	Explorer
42	LOCK	NW	January 26, 1995	RN	Explorer
43	PETE	SW	January 26, 1995	RN	Explorer
1995-1996 Field Season					
44	AITC	SH	November 17, 1995	BH	W. Discoverer
45	ARCT	SH	November 17, 1995	RN LB	Explorer
46	PENG	SH	November 17, 1995	RN LB	Explorer
47	BAIL	SH	November 18, 1995	BH	W. Discoverer
48	HANN	SH	November 18, 1995	RN LB	Explorer
49	HYDR	NW	November 18, 1995	BH	W. Discoverer
50	WHAL	SH	November 18, 1995	RN LB	Explorer
51	ALMI	NW	November 19, 1995	BH	W. Discoverer
52	ALMI	NW	November 19, 1995	RN LB	Explorer
53	CUVE	NW	November 19, 1995	RN LB	Explorer
54	CUVE	NW	November 19, 1995	BH	W. Discoverer

	Site	Subarea	Date	Researcher(s)	Platform
55	JUBA	SH	November 20, 1995	BH SF	W. Discoverer
56	LOCK	NW	November 20, 1995	RN LB	Explorer
57	PETE	SW	November 20, 1995	RN LB	Explorer
58	TURR	SH	November 20, 1995	BH	W. Discoverer
59	LOOK	EI	November 21, 1995	BH SF	W. Discoverer
60	POPT	NW	November 21, 1995	RN LB	Explorer
61	CUVE	NW	November 27, 1995	RN LB	Explorer
62	LOCK	NW	November 27, 1995	RN LB	Explorer
63	LOOK	EI	November 27, 1995	BH SF	W. Discoverer
64	ORNE	NW	November 27, 1995	RN LB	Explorer
65	ALMI	NW	November 28, 1995	RN LB	Explorer
66	FERR	SH	November 28, 1995	BH SF	W. Discoverer
67	PENG	SH	November 28, 1995	BH SF	W. Discoverer
68	PETE	SW	November 28, 1995	RN LB	Explorer
69	TURR	SH	November 28, 1995	BH	W. Discoverer
70	AITC	SH	November 29, 1995	BH	W. Discoverer
71	BAIL	SH	November 29, 1995	RN LB	Explorer
72	HALF	SH	November 29, 1995	BH	W. Discoverer
73	ROBE	SH	November 29, 1995	BH	W. Discoverer
74	TELE	SH	November 29, 1995	RN LB	Explorer
75	BAIL	SH	November 30, 1995	SF	W. Discoverer
76	HANN	SH	November 30, 1995	BH	W. Discoverer
77	PAUL	NE	November 30, 1995	RN LB	Explorer
78	WHAL	SH	November 30, 1995	BH SF	W. Discoverer
79	AITC	SH	December 1, 1995	RN LB	Explorer
80	ARCT	SH	December 1, 1995	RN LB	Explorer
81	HYDR	NW	December 1, 1995	BH SF	W. Discoverer
82	MIKK	NW	December 1, 1995	BH SF	W. Discoverer
83	POPT	NW	December 1, 1995	BH SF	W. Discoverer
84	ALMI	NW	December 2, 1995	SF	W. Discoverer
85	CUVE	NW	December 2, 1995	BH	W. Discoverer
86	RONG	NW	December 2, 1995	BH	W. Discoverer
87	WILD	EI	December 2, 1995	RN LB	Explorer
88	PETE	SW	December 3, 1995	BH	W. Discoverer
89	PAUL	NE	December 9, 1995	BH	W. Discoverer
90	HOPE	NE	December 10, 1995	BH	W. Discoverer
91	JONA	NE	December 10, 1995	BH SF	W. Discoverer
92	AITC	SH	December 11, 1995	BH SF	W. Discoverer
93	PENG	SH	December 11, 1995	BH	W. Discoverer
94	ROBE	SH	December 11, 1995	BH	W. Discoverer
95	TURR	SH	December 11, 1995	BH	W. Discoverer
96	BAIL	SH	December 12, 1995	BH	W. Discoverer
97	HANN	SH	December 12, 1995	BH	W. Discoverer
98	PEND	SH	December 12, 1995	BH SF	W. Discoverer
99	ALMI	NW	December 13, 1995	BH	W. Discoverer
100	DORI	NW	December 13, 1995	BH	W. Discoverer
101	ORCA	SO	December 13, 1995	LB	Explorer
102	RONG	NW	December 13, 1995	BH	W. Discoverer
103	PETE	SW	December 14, 1995	BH	W. Discoverer
104	WILD	EI	December 14, 1995	LB	Explorer
105	HALF	SH	December 15, 1995	LB	Explorer
106	YANK	SH	December 15, 1995	LB	Explorer
107	ALMI	NW	December 16, 1995	LB	Explorer
108	PETE	SW	December 16, 1995	LB	Explorer
109	DORI	NW	December 17, 1995	LB	Explorer
110	TURR	SH	December 20, 1995	BH	W. Discoverer
111	PEND	SH	December 29, 1995	RN LB	Explorer
112	PENG	SH	January 12, 1996	RN BH	Endurance
113	WHAL	SH	January 12, 1996	RN BH	Endurance
114	BAIL	SH	January 13, 1996	RN BH	Endurance

	Site	Subarea	Date	Researcher(s)	Platform
115	DORI	NW	January 14, 1996	RN BH	Endurance
116	LOCK	NW	January 14, 1996	RN BH	Endurance
117	ASTR	NW	January 15, 1996	RN BH	Endurance
118	HOPE	NE	January 15, 1996	RN BH	Endurance
119	PAUL	NE	January 16, 1996	RN BH	Endurance
120	CUVE	NW	January 19, 1996	RD RP	Livonia
121	MIKK	NW	January 19, 1996	RD RP	Livonia
122	MIKK	NW	January 19, 1996	RD RP	Livonia
123	DEVI	NE	January 20, 1996	RN BH	Endurance
124	LAGO	SW	January 21, 1996	RD RP	Livonia
125	POUR	SW	January 21, 1996	RD RP	Livonia
126	BROW	NE	January 22, 1996	RN BH	Endurance
127	PETE	SW	January 23, 1996	RD RP	Livonia
128	PLEN	SW	January 23, 1996	RD RP	Livonia
129	YALO	SW	January 23, 1996	RD RP	Livonia
130	DORI	NW	January 24, 1996	RD RP	Livonia
131	LOCK	NW	January 24, 1996	RD RP	Livonia
132	MARA	NE	January 25, 1996	RN BH	Endurance
133	NEKO	NW	January 25, 1996	RD RP	Livonia
134	ORNE	NW	January 25, 1996	RD RP	Livonia
135	RONG	NW	January 25, 1996	BH	W. Discoverer
136	MELC	NW	January 26, 1996	RD RP	Livonia
137	POPT	NW	January 26, 1996	RD RP	Livonia
138	SPRI	NW	January 26, 1996	RD RP	Livonia
139	BAIL	SH	January 27, 1996	RD RP	Livonia
140	HANN	SH	January 27, 1996	RD RP	Livonia
141	JONA	NE	January 30, 1996	RN BH	Endurance
142	PAUL	NE	January 31, 1996	RN BH	Endurance
143	AITC	SH	February 2, 1996	RD RP	Livonia
144	ARCT	SH	February 2, 1996	RD RP	Livonia
145	WHAL	SH	February 2, 1996	RN	Livonia
146	NEKO	NW	February 3, 1996	RN RD RP BH	Livonia
147	WATE	NW	February 3, 1996	RN RD RP BH	Livonia
148	CUVE	NW	February 4, 1996	RN RD RP BH	Livonia
149	PETE	SW	February 4, 1996	RN RD RP BH	Livonia
150	AITC	SH	February 9, 1996	RD RP	Livonia
151	ROBE	SH	February 9, 1996	BH RP	Livonia
152	BROW	NE	February 10, 1996	BH RP	Livonia
153	DURV	NE	February 10, 1996	RP BH	Livonia
154	ASTR	NW	February 11, 1996	BH RP	Livonia
155	MIKK	NW	February 11, 1996	RP BH	Livonia
156	RONG	NW	February 11, 1996	BH RP	Livonia
157	CUVE	NW	February 12, 1996	BH RP	Livonia
158	NEKO	NW	February 12, 1996	BH RP	Livonia
159	LOCK	NW	February 13, 1996	BH RP	Livonia
160	PLEN	SW	February 13, 1996	BH RP	Livonia
1996-1997 Field Season					
161	YANK	SH	November 23, 1996	RN WT SF	Explorer
162	LOCK	NW	November 24, 1996	RN SF WT	Explorer
163	ALMI	NW	November 25, 1996	RN SF	Explorer
164	HYDR	NW	November 25, 1996	SF WT RN	Explorer
165	TELE	SH	November 26, 1996	RN	Explorer
166	WHAL	SH	November 26, 1996	RN	Explorer
167	PAUL	NE	November 27, 1996	RN WT	Explorer
168	PENG	SH	November 30, 1996	RN SF	W. Discoverer
169	EDEN	NE	December 1, 1996	RN SF	W. Discoverer
170	HERO	NE	December 1, 1996	RN SF	W. Discoverer
171	PAUL	NE	December 1, 1996	RN	W. Discoverer
172	BERN	NW	December 2, 1996	RN	W. Discoverer

	Site	Subarea	Date	Researcher(s)	Platform
173	HALF	SH	December 2, 1996	RN SF	W. Discoverer
174	BAIL	SH	December 3, 1996	RN	W. Discoverer
175	HANN	SH	December 3, 1996	RN SF	W. Discoverer
176	ALMI	NW	December 4, 1996	RN SF	W. Discoverer
177	CUVE	NW	December 4, 1996	RN SF	W. Discoverer
178	ORNE	NW	December 4, 1996	RN SF	W. Discoverer
179	RONG	NW	December 4, 1996	RN SF	W. Discoverer
180	PETE	SW	December 5, 1996	RN SF	W. Discoverer
181	LOOK	EI	December 30, 1996	LB	Hanseatic
182	PAUL	NE	December 31, 1996	LB	Hanseatic
183	PETE	SW	January 9, 1997	LB	Hanseatic
184	PETE	SW	January 29, 1997	LB	Hanseatic
185	HANN	SH	January 30, 1997	LB	Hanseatic
186	PETE	SW	February 8, 1997	LB	Hanseatic
187	PETE	SW	February 16, 1997	LB	Hanseatic
188	AITC	SH	February 17, 1997	RN	Explorer
189	ALMI	NW	February 18, 1997	RN	Explorer
190	CUVE	NW	February 18, 1997	RN	Explorer
191	PLEN	SW	February 19, 1997	RN	Explorer
192	BAIL	SH	February 21, 1997	RN	Explorer
193	DEVI	NE	February 23, 1997	RN ST	Explorer
194	RUMC	NE	February 23, 1997	RN	Explorer
1997-1998 Field Season					
195	PETE	SW	November 23, 1997	RN SF	W. Discoverer
196	WATE	NW	November 23, 1997	RN SF	W. Discoverer
197	LOCK	NW	November 24, 1997	RN SF	W. Discoverer
198	AITC	SH	November 25, 1997	RN SF	W. Discoverer
199	PENG	SH	November 26, 1997	RN SF	W. Discoverer
200	TURR	SH	November 26, 1997	RN SF	W. Discoverer
201	ALMI	NW	November 27, 1997	RN SF	W. Discoverer
202	ARCT	SH	November 29, 1997	RN	W. Discoverer
203	PENG	SH	December 1, 1997	RN SF LS MB	Explorer
204	GOUR	NW	December 2, 1997	RN SF	Explorer
205	BAIL	SH	December 3, 1997	RN SF	Explorer
206	HANN	SH	December 3, 1997	RN SF	Explorer
207	ALMI	NW	December 4, 1997	RN SF	Explorer
208	CUVE	NW	December 4, 1997	RN	Explorer
209	ORNE	NW	December 4, 1997	RN	Explorer
210	RONG	NW	December 4, 1997	SF	Explorer
211	LOCK	NW	December 5, 1997	RN SF	Explorer
1998-1999 Field Season					
212	ARCT	SH	November 26, 1998	RN SF	Explorer
213	HALF	SH	November 26, 1998	RN SF	Explorer
214	ORNE	NW	November 27, 1998	RN SF	Explorer
215	RONG	NW	November 27, 1998	RN SF	Explorer
216	WATE	NW	November 27, 1998	RN SF	Explorer
217	LOCK	NW	November 28, 1998	RN SF	Explorer
218	CUVE	NW	December 5, 1998	RN SF	Explorer
219	ORNE	NW	December 6, 1998	RN SF	Explorer
220	POPT	NW	December 6, 1998	RN SF	Explorer
221	BAIL	SH	December 7, 1998	RN SF	Explorer
222	HANN	SH	December 7, 1998	RN SF	Explorer
223	HOPE	NE	December 8, 1998	RN SF	Explorer
224	PENG	SH	December 9, 1998	RN SF	Explorer
225	BAIL	SH	January 12, 1999	RN SF	Endurance
226	PENG	SH	January 12, 1999	RN SF	Endurance
227	BROW	NE	January 13, 1999	RN SF	Endurance
228	LOCK	NW	January 14, 1999	RN SF	Endurance

	Site	Subarea	Date	Researcher(s)	Platform
229	VAPO	SH	January 16, 1999	RN SF	Endurance
230	WILD	EI	January 17, 1999	RN	Endurance
231	AITC	SH	January 18, 1999	RN	Endurance
232	PENG	SH	January 19, 1999	RD ST	Vavilov
233	BAIL	SH	January 20, 1999	RD ST	Vavilov
234	GOUR	NW	January 20, 1999	RN	Endurance
235	YANK	SH	January 20, 1999	RD ST	Vavilov
236	PAUL	NE	January 21, 1999	RN RD ST	Vavilov
237	PETE	SW	January 22, 1999	RN RD ST	Vavilov
238	NEKO	NW	January 23, 1999	RD ST	Vavilov
239	AITC	SH	January 24, 1999	RN RD ST	Vavilov
1999-2000 Field Season					
240	BROW	NE	November 25, 1999	LB BP	Cal Star
241	PAUL	NE	November 25, 1999	LB BP	Cal Star
242	WHAL	SH	November 26, 1999	LB BP	Cal Star
243	YANK	SH	November 26, 1999	LB BP	Cal Star
244	LOCK	NW	November 27, 1999	LB BP	Cal Star
245	ORNE	NW	November 27, 1999	LB BP	Cal Star
246	LEMA	SW	November 28, 1999	LB BP	Cal Star
247	PLEN	SW	November 28, 1999	LB BP	Cal Star
248	DANC	NW	November 29, 1999	LB BP	Cal Star
249	AITC	SH	December 13, 1999	RN	Cal Star
250	FORT	SH	December 13, 1999	RN	Cal Star
251	YANK	SH	December 13, 1999	RN	Cal Star
252	PAUL	NE	December 14, 1999	RN	Cal Star
253	ASTR	NW	December 15, 1999	SF	Shuleykin
254	BROW	NE	December 15, 1999	RN	Cal Star
255	CRYS	NE	December 15, 1999	RN	Cal Star
256	PENG	SH	December 15, 1999	SF	Shuleykin
257	NEKO	NW	December 16, 1999	SF	Shuleykin
258	ORNE	NW	December 16, 1999	RN	Cal Star
259	PETE	SW	December 16, 1999	RN	Cal Star
260	RONG	NW	December 16, 1999	SF	Shuleykin
261	HYDR	NW	December 17, 1999	RN	Cal Star
262	LOCK	NW	December 17, 1999	RN	Cal Star
263	FOYN	NW	December 18, 1999	SF	Shuleykin
264	HANN	SH	December 18, 1999	RN	Cal Star
265	PEND	SH	December 18, 1999	RN	Cal Star
266	TELE	SH	December 18, 1999	RN	Cal Star
267	WHAL	SH	December 18, 1999	RN	Cal Star
268	BAIL	SH	December 19, 1999	SF	Shuleykin
269	AITC	SH	January 9, 2000	SF	Cal Star
270	BALD	NE	January 11, 2000	SF	Cal Star
271	DEVI	NE	January 11, 2000	SF	Cal Star
272	ALMI	NW	January 13, 2000	SF	Cal Star
273	LOCK	NW	January 13, 2000	SF	Cal Star
274	HANN	SH	January 14, 2000	SF	Cal Star
275	WILD	EI	January 15, 2000	SF	Cal Star
276	DEVI	NE	January 17, 2000	RD	Explorer
277	VIEW	NE	January 17, 2000	RD	Explorer
278	HANN	SH	January 18, 2000	RD	Explorer
279	LOCK	NW	January 19, 2000	RD	Explorer
280	PETE	SW	January 20, 2000	RD	Explorer
281	HERO	NE	January 21, 2000	RN	Shuleykin
282	ORNE	NW	January 21, 2000	RD	Explorer
283	PAUL	NE	January 21, 2000	RN	Shuleykin
284	HALF	SH	January 22, 2000	RN	Shuleykin
285	CUVE	NW	January 23, 2000	RN	Shuleykin
286	LOCK	NW	January 23, 2000	RN	Shuleykin

	Site	Subarea	Date	Researcher(s)	Platform
287	ORNE	NW	January 23, 2000	RN	Shuleykin
288	NEKO	NW	January 24, 2000	RN	Shuleykin
289	PETE	SW	January 24, 2000	RN	Shuleykin
290	VERN	SW	January 24, 2000	RN	Shuleykin
291	HANN	SH	January 25, 2000	RN	Shuleykin
292	WHAL	SH	January 25, 2000	RN	Shuleykin
	2000-2001 Field Season				
293	WILD	EI	December 10, 2000	RN	Cal Star
294	BROW	NE	December 11, 2000	RN	Cal Star
295	PAUL	NE	December 11, 2000	RN	Cal Star
296	WHAL	SH	December 12, 2000	RN	Cal Star
297	LOCK	NW	December 13, 2000	RN	Cal Star
298	PETE	SW	December 13, 2000	RN	Cal Star
299	PLEN	SW	December 13, 2000	RN	Cal Star
300	ALMI	NW	December 14, 2000	RN	Cal Star
301	ORNE	NW	December 14, 2000	RN	Cal Star
302	AITC	SH	December 15, 2000	RN	Cal Star
303	HANN	SH	December 15, 2000	RN	Cal Star
304	AITC	SH	December 24, 2000	SF	Cal Star
305	YANK	SH	December 24, 2000	SF LF	Cal Star
306	BROW	NE	December 25, 2000	SF	Cal Star
307	PAUL	NE	December 25, 2000	SF LF	Cal Star
308	HYDR	NW	December 26, 2000	SF LF	Cal Star
309	LOCK	NW	December 27, 2000	SF	Cal Star
310	PLEN	SW	December 27, 2000	SF LF	Cal Star
311	STON	SW	December 28, 2000	SF LF	Cal Star
312	HANN	SH	December 30, 2000	SF LF	Cal Star
313	BROW	NE	January 9, 2001	SF	Cal Star
314	PAUL	NE	January 9, 2001	SF	Cal Star
315	BALD	NE	January 10, 2001	SF	Cal Star
316	DEVI	NE	January 10, 2001	SF	Cal Star
317	BAIL	SH	January 11, 2001	SF	Cal Star
318	DEVI	NE	January 11, 2001	SF	Cal Star
319	WHAL	SH	January 11, 2001	SF	Cal Star
320	LOCK	NW	January 12, 2001	SF	Cal Star
321	RONG	NW	January 12, 2001	SF	Cal Star
322	BLAI	SW	January 13, 2001	SF	Cal Star
323	BOOT	SW	January 13, 2001	SF	Cal Star
324	LOCK	NW	January 13, 2001	RN RD	Cal Star
325	PETE	SW	January 13, 2001	SF	Cal Star
326	PETE	SW	January 14, 2001	SF	Cal Star
327	AITC	SH	January 22, 2001	RN	Cal Star
328	CUVE	NW	January 23, 2001	RN RD	Cal Star
329	ORNE	NW	January 23, 2001	RN RD	Cal Star
330	BAIL	SH	January 24, 2001	RN RD	Cal Star
331	BOOT	SW	January 24, 2001	RN RD	Cal Star
332	PLEN	SW	January 24, 2001	RN RD	Cal Star
333	PLEN	SW	January 25, 2001	RD	Cal Star
334	BAIL	SH	January 26, 2001	RN RD	Cal Star
335	PAUL	NE	January 26, 2001	RD	Cal Star
336	BURD	NE	January 27, 2001	RD	Cal Star
337	FORT	SH	February 1, 2001	RN	Cal Star
338	BROW	NE	February 2, 2001	RN	Cal Star
339	PAUL	NE	February 2, 2001	RN	Cal Star
340	MIKK	NW	February 3, 2001	RN	Cal Star
341	BOOT	NW	February 4, 2001	RN	Cal Star
342	LOCK	NW	February 4, 2001	RN	Cal Star
343	PYPT	NW	February 5, 2001	RN	Cal Star
344	VAPO	SH	February 6, 2001	RN	Cal Star

	Site	Subarea	Date	Researcher(s)	Platform
2001-2002 Field Season					
345	WILD	EI	December 9, 2001	RN SF CE	Endeavour
346	FALS	NE	December 10, 2001	RN SF CE	Endeavour
347	SNOW	NE	December 10, 2001	RN SF CE	Endeavour
348	BROW	NE	December 11, 2001	RN SF CE	Endeavour
349	PAUL	NE	December 11, 2001	RN SF CE	Endeavour
350	AITC	SH	December 12, 2001	RN SF CE	Endeavour
351	WHAL	SH	December 12, 2001	RN SF CE	Endeavour
352	ALMI	NW	December 13, 2001	RN SF CE	Endeavour
353	CUVE	NW	December 13, 2001	RN SF CE	Endeavour
354	DANC	NW	December 14, 2001	RN SF CE	Endeavour
355	PRIE	NW	December 14, 2001	RN SF CE	Endeavour
356	LOCK	NW	December 15, 2001	RN SF CE	Endeavour
357	AITC	SH	December 20, 2001	JC LGC	Endeavour
358	PAUL	NE	December 21, 2001	JC LC	Endeavour
359	SNOW	NE	December 21, 2001	JC LC	Endeavour
360	BROW	NE	December 22, 2001	JC LC	Endeavour
361	JADE	NE	December 22, 2001	JC LC	Endeavour
362	JONA	NE	December 22, 2001	JC LC	Endeavour
363	HYDR	NW	December 23, 2001	JC LC	Endeavour
364	LECO	NW	December 23, 2001	JC LC	Endeavour
365	ALMI	NW	December 24, 2001	JC LC	Endeavour
366	BOOT	NW	December 24, 2001	JC LC	Endeavour
367	ORNE	NW	December 24, 2001	JC LC	Endeavour
368	LOCK	NW	December 25, 2001	JC LC	Endeavour
369	MITC	SH	December 26, 2001	JC LC	Endeavour
370	AITC	SH	December 30, 2001	RP	Endeavour
371	OBEL	NE	January 1, 2002	RP	Endeavour
372	BROW	NE	January 2, 2002	RP	Endeavour
373	JADE	NE	January 2, 2002	RP	Endeavour
374	SNOW	NE	January 2, 2002	RP	Endeavour
375	HYDR	NW	January 3, 2002	RP	Endeavour
376	CUVE	NW	January 4, 2002	RP	Endeavour
377	PLEN	SW	January 4, 2002	RP	Endeavour
378	LOCK	NW	January 5, 2002	RP	Endeavour
379	MITC	SH	January 6, 2002	RP	Endeavour
380	WHAL	SH	January 6, 2002	RP	Endeavour
381	WILD	EI	January 8, 2002	SF	Endeavour
382	AITC	SH	January 11, 2002	RP WT	Endeavour
383	DEVI	NE	January 12, 2002	RP WT	Endeavour
384	PERS	NE	January 12, 2002	RP WT	Endeavour
385	BROW	NE	January 13, 2002	RP WT	Endeavour
386	SNOW	NE	January 13, 2002	RP WT	Endeavour
387	CUVE	NW	January 14, 2002	RP WT	Endeavour
388	ALMI	NW	January 15, 2002	RP WT	Endeavour
389	BOOT	SW	January 15, 2002	RP WT	Endeavour
390	PLEN	SW	January 15, 2002	RP WT	Endeavour
391	LOCK	NW	January 16, 2002	RP WT	Endeavour
392	BAIL	NE	January 17, 2002	RP WT	Endeavour
393	AITC	SH	January 22, 2002	RD LS	Endeavour
394	BROW	NE	January 24, 2002	RD LS	Endeavour
395	DEVI	NE	January 24, 2002	RD LS	Endeavour
396	PAUL	NE	January 25, 2002	RD LS	Endeavour
397	TAYH	NE	January 25, 2002	RD LS	Endeavour
398	ALMI	NW	January 27, 2002	RD LS	Endeavour
399	ORNE	NW	January 27, 2002	RD LS	Endeavour
400	LOCK	NW	January 28, 2002	RD LS	Endeavour
401	AITC	SH	February 2, 2002	MM	Endeavour
402	PAUL	NE	February 3, 2002	MM	Endeavour

	Site	Subarea	Date	Researcher(s)	Platform
403	BROW	NE	February 4, 2002	MM	Endeavour
404	TAYH	NE	February 4, 2002	MM	Endeavour
405	WHAL	NE	February 5, 2002	MM	Endeavour
406	LOCK	NW	February 6, 2002	MM	Endeavour
407	ALMI	NW	February 7, 2002	MM	Endeavour
408	CUVE	NW	February 7, 2002	MM	Endeavour
409	ORNE	NW	February 7, 2002	MM	Endeavour
410	PLEN	SW	February 8, 2002	MM	Endeavour
411	CUVE	NW	February 15, 2002	RN	Endeavour
412	LOCK	NW	February 15, 2002	RN	Endeavour
413	ORNE	NW	February 15, 2002	RN	Endeavour
414	PETE	SW	February 16, 2002	RN	Endeavour
415	ALMI	NW	February 17, 2002	RN	Endeavour
416	GOUV	NW	February 17, 2002	RN	Endeavour
417	BAIL	SH	February 18, 2002	RN	Endeavour
418	TELE	SH	February 18, 2002	RN	Endeavour
419	WHAL	SH	February 18, 2002	RN	Endeavour
420	PEPO	NE	February 19, 2002	RN	Endeavour
421	SNOW	NE	February 19, 2002	RN	Endeavour
422	HILL	NE	February 20, 2002	RN	Endeavour
423	PAUL	NE	February 20, 2002	RN	Endeavour
424	TAYH	NE	February 20, 2002	RN	Endeavour
425	WILD	EI	February 21, 2002	RN	Endeavour
426	AMPH	SO	February 22, 2002	RN	Endeavour
2002-2003 Field Season					
427	WILD	EI	December 6, 2002	RN	Endeavour
428	GOUR	NW	December 7, 2002	RN	Endeavour
429	BAIL	SH	December 8, 2002	RN	Endeavour
430	AITC	SH	December 8, 2002	RN	Endeavour
431	ORNE	NW	December 9, 2002	RN	Endeavour
432	LOCK	NW	December 9, 2002	RN	Endeavour
433	PETE	SW	December 10, 2002	RN	Endeavour
434	NEKO	NW	December 11, 2002	RN	Endeavour
435	ALMI	NW	December 11, 2002	RN	Endeavour
436	LECO	NW	December 12, 2002	RN	Endeavour
437	DORI	NW	December 12, 2002	RN	Endeavour
438	WILD	EI	December 28, 2002	RP	Endeavour
439	LOOK	EI	December 28, 2002	RP	Endeavour
440	AITC	SH	December 29, 2002	RP	Endeavour
441	MITC	SH	December 29, 2002	RP	Endeavour
442	YANK	SH	December 29, 2002	RP	Endeavour
443	BAIL	SH	December 30, 2002	RP	Endeavour
444	WHAL	SH	December 30, 2002	RP	Endeavour
445	TELE	SH	December 30, 2002	RP	Endeavour
446	EAGL	NE	December 31, 2002	RP	Endeavour
447	BROW	NE	January 1, 2003	RP	Endeavour
448	HYDR	NW	January 1, 2003	RP	Endeavour
449	CUVE	NW	January 2, 2003	RP	Endeavour
450	LOCK	NW	January 2, 2003	RP	Endeavour
451	PLEN	SW	January 3, 2003	RP	Endeavour
452	ALMI	NW	January 3, 2003	RP	Endeavour
453	AITC	SH	January 8, 2003	SF	Endeavour
454	MITC	SH	January 8, 2003	SF	Endeavour
455	BAIL	SH	January 9, 2003	SF	Endeavour
456	WHAL	SH	January 9, 2003	SF	Endeavour
457	TELE	SH	January 9, 2003	SF	Endeavour
458	PAUL	NE	January 10, 2003	SF	Endeavour
459	BROW	NE	January 10, 2003	SF	Endeavour
460	HYDR	NW	January 11, 2003	SF	Endeavour

	Site	Subarea	Date	Researcher(s)	Platform
461	NEKO	NW	January 11, 2003	SF	Endeavour
462	ALMI	NW	January 12, 2003	SF	Endeavour
463	LOCK	NW	January 12, 2003	SF	Endeavour
464	DETA	SW	January 13, 2003	SF	Endeavour
465	FISH	SW	January 13, 2003	SF	Endeavour
466	PLEN	SW	January 14, 2003	SF	Endeavour
467	AITC	SH	January 19, 2003	RD	Endeavour
468	DEVI	NE	January 20, 2003	RD	Endeavour
469	PAUL	NE	January 20, 2003	RD	Endeavour
470	MADD	NE	January 21, 2003	RD	Endeavour
471	SIFF	NW	January 21, 2003	RD	Endeavour
472	BAIL	SH	January 22, 2003	RD	Endeavour
473	PETE	SW	January 23, 2003	RD	Endeavour
474	LOCK	NW	January 25, 2003	RD	Endeavour
475	ALMI	NW	January 25, 2003	RD	Endeavour
476	NEKO	NW	January 25, 2003	RD	Endeavour
477	AITC	SH	January 30, 2003	MM	Endeavour
478	SNOW	NE	January 31, 2003	MM	Endeavour
479	FALS	NE	January 31, 2003	MM	Endeavour
480	BROW	NE	February 1, 2003	MM	Endeavour
481	PAUL	NE	February 1, 2003	MM	Endeavour
482	BAIL	SH	February 2, 2003	MM	Endeavour
483	WHAL	SH	February 2, 2003	MM	Endeavour
484	PETE	SW	February 3, 2003	MM	Endeavour
485	SHUM	SW	February 4, 2003	MM	Endeavour
486	LOCK	NW	February 6, 2003	MM	Endeavour
487	ALMI	NW	February 6, 2003	MM	Endeavour
488	MCAL	SW	February 12, 2003	MB	Endeavour
489	LOCK	NW	February 13, 2003	MB	Endeavour
490	PETE	SW	February 13, 2003	MB	Endeavour
491	ALMI	NW	February 14, 2003	MB	Endeavour
492	NEKO	NW	February 14, 2003	MB	Endeavour
493	ORNE	NW	February 14, 2003	MB	Endeavour
494	CUVE	NW	February 14, 2003	MB	Endeavour
495	BAIL	SH	February 15, 2003	MB	Endeavour
496	WHAL	SH	February 15, 2003	MB	Endeavour
497	TELE	SH	February 15, 2003	MB	Endeavour
498	PAUL	NE	February 16, 2003	MB	Endeavour
499	SNOW	NE	February 16, 2003	MB	Endeavour
500	CAMP	NE	February 17, 2003	MB	Endeavour
501	DEVI	NE	February 17, 2003	MB	Endeavour
502	WILD	EI	February 18, 2003	MB	Endeavour
503	GIBB	SO	February 19, 2003	MB	Endeavour

Key (Antarctic Site Inventory researchers):

RN	Ron Naveen
RD	Rosemary Dagit
SF	Steven Forrest
MB	Matt Becker
LB	Louise Blight
JC	John Carlson
LC	Laura Gittings Carlson
CE	Chris Edelen
LF	Louise Forrest
BH	Brent Houston
MM	Megan McOsker
RP	Richard Polatty
LS	Laina Shill
WT	Wayne Z. Trivelpiece
ST	Susan G. Trivelpiece

Appendix 2: Specific instructions for Antarctic Site Inventory researchers.

> Inventory researchers and the project's principal investigator follow particular and standard operating procedures with respect to data collection, data evaluation, and record keeping. These procedures are described below.

Prior to the start of each site survey, the investigators:

- Record the ship's GPS reading, and compare it to that obtained from the team's hand-held GPS receivers;
- Record Beaufort wind force, air and water temperatures in ˚C., and the amount of ice and cloud cover; and
- Photograph the landing site, from port to starboard, and record bearings and distances from the ship to prominent features and landmarks on shore.

Immediately upon reaching the landing site, the investigators:

- Record the GPS reading and, if necessary, find a safe location for placing the GPS base unit;
- Take additional photographs if necessary, and estimate the dimensions of the landing beach and record any other prominent features or landmarks; and
- Take and record compass bearings and measure/estimate/record distances from the landing beach to prominent features and to discrete groups or assemblages of fauna and flora.

While ashore, the investigators:

- Use hand-held GPS receivers to document waypoints as necessary for general surveying and mapping purposes, and to specifically record the positions of prominent features and discrete groups or assemblages of fauna and flora;
- Determine/identify other access and exit points to the landing site, and describe groups or assemblages of fauna and flora in close proximity to all access and exit points;
- Establish a route for censusing seals that may be present;
- Locate vantage points from which serial, visit-to-visit and season-to-season photodocumentation and observation of prominent features and discrete groups or assemblages of fauna and flora can be accomplished;
- Maintain a running log of the date and the location where each photograph is taken, and as appropriate photograph discrete groups of penguins, flying birds, seals (wallows or haul-out sites), and floral assemblages that are easily reached by visitors from the landing sites, and those which are difficult or impossible to reach in the normal course of a visitor landing and which, therefore, may serve as "control groups";
- With respect to selected control and experimental groups of penguins and flying birds (and according to the stage of the breeding cycle), record and estimate: the number of active nests; the number of adults present (whether incubating or not); the number of eggs and eggs per nest (as possible); the number of chicks (and chicks per nest, as possible); the age of chicks (in weeks); and with respect to penguins, the percentage of chicks that are creched; counts of adults, active nests, and chicks should be repeated until three counts are obtained, with the highest count being no more than 8% higher than the lowest count; and
- With respect to seals, record the number, age, condition, and location of seals in wallows and hauled-out on beaches.

Following each site survey, the investigators:

- Log field data onto standard data sheets, and update the master film log; data sheets are duplicated and the originals are stored for safe-keeping;
- Review data to insure that each team member is cognizant of the other's effort and coverage, and compare maps and sketches to insure accuracy and agreement; and
- Determine data collection priorities for the next visit to the site.

At the end of each field season, the principal investigator reviews the data to ascertain which sites were visited and how often they were visited, and whether sites were visited in both the 1st and 2nd deployments (i.e. in the austral spring, November/December, and the austral summer, January/February). These summary data are reviewed in turn to evaluate whether the selection of vessels and expedition leaders produced the desired coverage of sites for the season, and to make necessary scheduling adjustments for the next field season.

The principal investigator also reviews and analyzes the data sheets from every site visit to insure that data have been collected consistently and recorded accurately. These data then are logged into compute files maintained by the principal investigator.

Appendix 3: Improving Antarctic Site Inventory Census Methods

> In the 1st edition of the *Site Compendium*, Oceanites reported on a power analysis study regarding census methods of the Conservation Of Antarctic Living Marine Resources (CCAMLR) Ecosystem Monitoring Program (CEMP) published by the Scientific Committee for the Conservation of Antarctic Marine Living Resources, and used throughout the Antarctic.
>
> These census methods require, for penguin nest and chick counts, three counts that are “within 5-10% range of each other.” The power analysis suggested a tightening so that the highest count is “no more than 8% higher than the lowest count,” to ensure that Type I and Type II statistical errors are avoided.
>
> The power analysis from the 1st edition of the *Site Compendium* is reprinted below.

A power analysis was undertaken to examines possibilities for improving the census methods for the Antarctic Site Inventory (ASI), particularly when large colonies of penguins are involved. These large assemblages, given the vagaries of often difficult terrain and time pressures facing ASI researchers, present difficult census situations.

In its original iteration, the methodology for the Inventory required that

> . . . counts of adults, active nests, and chicks should be repeated until three counts are obtained that are within 5-10% range of each other.

This derives from the CEMP Standard Methods 1992, which, for collecting data on parameters that are relevant to ascertaining penguin breeding population size and penguin breeding success (e.g. numbers of nests, numbers of chicks), states that:

> Three separate counts should be made of each of the selected colonies on the same day. if one of the three counts [of the relevant parameter] differs more than 10% from the others, a fourth count should be made on the same day as the other three counts. (CCAMLR, 1992)

This three-count standard is followed in other Antarctic penguin studies, for example the long-term study of *Pygoscelid* penguins in Admiralty Bay (W. Trivelpiece, pers. comm.), and is incorporated into the data forms utilized in the CCAMLR Ecosystem Monitoring (CEMP) program (CCAMLR, 1992).

The three-count technique had its genesis in the CEMP Working Group (SC-CAMLR, 1989), which suggested sampling strategies that should be able to detect a 10% or 20% change in a parameter with a significance level $\alpha = .01$ and a statistical power P $(=1-\beta) \geq 0.8$ (Agnew, 1989). Following Sokal and Rohlf (1981), Whitehead (1990) notes the following formula for calculating the necessary sample size for detecting a given, “true” difference between means:

$$n \geq 2 (sd/\Delta)^2 (t_{a,v} + t_{2(1-P),v})^2$$

where

- n = the required sample size (samples per year per site);
- sd = true standard deviation;
- Δ = the smallest true difference that is desired to detect;
- a = the significance level (i.e. the probability of rejecting a true null hypothesis of no difference among years);
- P = the desired probability that a difference will be found if it is large as Δ (P = the statistical power);
- $t_{a,v}$ = value from a two-tailed t-table with v degrees of freedom and corresponding to probability a; and
- $t_{2(1-P),v}$ = value from a two-tailed Student’s t-table with v degrees of freedom and corresponding to probability 2(1-P)

The degrees of freedom, v, would = r(n-1), where r = the number of years over which the effect is detected, and n = the sample size.

Solving for Δ, then

$$\sqrt{\frac{n}{2}} \geq (sd/□)\ (ta,v + t2(1\text{-}P),v)$$

and $$□ \geq \sqrt{\frac{2}{n}}\ (sd)\ (ta,v + t2(1\text{-}P),v)$$

The formula is solved iteratively to determine which levels of change may be detected with the required degree of confidence. The CEMP Working Group standard suggests there should a 99% confidence (□ □ .01) that when a change has been detected, it has actually occurred (which, in statistical parlance, avoids what is deemed a Type I error, where a significant change is detected but does not actually exist) and only a 20% chance (P ≥ 0.8) of missing a significant change (which, in statistical parlance, avoids what is deemed a Type II error, where no significant change is detected but one actually exists). Translating this mandate to the context of the Antarctic Site Inventory, there should be a 99% confidence of detecting a change from one season to the next in one of the relevant biological parameters being examined (i.e. numbers of nests, numbers of adults, numbers of chicks) and only a 20% chance of missing a significant change in one of these parameters.

The Inventory's methodology requires three counts of each parameter; thus, n = 3. In terms of the Sokal and Rohlf formula, then, the degrees of freedom would be v = r(n-1) = 4 (where r, the number of years over which the effect is detected, = 2). Then, from the appropriate t-tables, the ta,v corresponding to □ □ .01 is 4.60 and the t2(1-P),v corresponding to P ≥ 0.8 is 0.93. The three-count, 5-10% mandate of the methodology may be examined in two ways:

• **Symmetrical counts**. First, it might be assumed that the minimum and the maximum of the three counts are an equal percentage away from the mean of the three counts. So, if there were three specific counts of 95, 100, and 105, the standard deviation (sd) would be 5.0; if there were three counts of x, x + k, and x - k, the standard deviation would be k; or, if there were three counts of x, x + k% of x, x - k% of x, the standard deviation would be k% of x (where x = mean).

Thus, if project investigators accept three counts within 5% of the mean (x) of the three counts, according to the Sokal and Rohlf formula, they would be able to detect changes greater than or equal to 23% of the mean with a power of P = .8; from the formula above:

$$□ \geq \sqrt{\frac{2}{n}}\ (sd)\ (ta,v + t2(1\text{-}P),v)$$

□ ≥ (.8165, the square root of 2/3)(.05x, the sd) (5.54, the sum of ta,v + t2(1-P),v)); and

□ ≥ .23x

But if project investigators accept three counts within 4% of the mean (x) of the three counts, the investigators will be able to detect changes no less than 18% of the mean with a power of P = .8:

□ ≥ (.8165)(.04x)(5.54)

□ ≥ .18x

The ability to detect an 18% level of change with a statistical power of 0.8 complies within the mandate of the CEMP Working Group ("sampling strategies that should be able to detect a 10% or 20% change in a parameter with a significance level □ □ .01 and a statistical power P (=1-□) ≥ 0.8"). In practical terms, if the count in question is of nests in a particular penguin colony, where the mean number of nests is 100, the CEMP Working Group standard is met if investigators' counts vary no more than 4% from the mean (the counts would have to be no lower than 96 and no greater than 104). If the mean number of nests is 500, the highest acceptable count meeting the □ □ .01/P≥.8 mandate would be 520 and the lowest, 480.[1]

[1] The Sokal and Rohlf equation also may be examined to determine the percentage of difference (k) that counts should maintain from their mean to permit an exact level of change (e.g. 20% of x) to be detected at the requisite power (e.g. P = .08); thus:

$$□ \geq \sqrt{\frac{2}{n}}\ (kx)\ (t_{a,v} = t_{2(1-P),v})$$

.20x ≥ (.8165)(kx)(5.54)

If it is desired to detect a 10% change with the same statistical power, the Sohal and Rohlf formula may be examined to determine by how much investigators would have to tighten their counts:

$$.10x \geq (.8165)(kx)(5.54),$$

where k = the percentage limit by which counts may vary from their mean, and

$$k \;\square\; .10/(.8165)(5.54)$$

$$\square\; .022\ x,$$

which means that counts would have to be tightened to within 2.2% of the mean. So where the mean number of nests is 100, detecting a smaller change with the same statistical power would require counts to be no lower than 97.8 and no greater than 102.2; if the mean number of nests is 500, the highest acceptable count in this example would be 511 and the lowest, 489

Similarly, the formula may be examined to determine how much counts would need to tighten if the power is increased. Increasing the power to P = .9 increases the corresponding value of t2(1-P),v to 1.53 (ta,v remains = 4.60); then, to detect a 20% change:

$$.20x \geq (.8165)(kx)(6.13)$$

$$k \;\square\; .20/(.8165)(6.13)$$

$$\square\; .039\ x,$$

which means that counts could vary no more than 3.9% from the mean. If it is desired to detect a 10% change with a power P = .9, then:

$$.10x \geq (.8165)(kx)(6.13)$$

$$k \;\square\; .10/(.8165)(6.13)$$

$$\square\; .019\ x,$$

which means that counts could vary no more than 1.9% from the mean. So in this case, if the mean number of nests is 100, counts have to range between 98.1 and 101.9.

• **Unsymmetrical counts**. In a practical sense, the most difficult aspect of the first scenario is the apparent need to keep a running tab of means while counts are proceeding in the field. This would be particularly burdensome where large colonies are being counted and time is of the essence. A second scenario addresses this concern by focusing on the lowest count, and assumes that the highest count will not be greater that a certain percentage above the lowest.

The maximum standard deviation occurs when the two lowest numbers are the same and the third is 10% higher (e.g. 100, 100, 110, in three counts of the number of nests in a particular penguin colony). In this specific, numerical example, the standard deviation is 5.77, which is higher than that noted in (a) above where the three counts varied only by a certain percentage from the mean of all three counts. The general pattern of counts in the second scenario, therefore, would be y, y, ky, where k represents a certain percentage above the lowest count, y. This leads to the standard deviation

$$sd = \left(\frac{k - 1}{\sqrt{3}}\right)(y)$$

which, inserted into the Sokal and Rohlf formula (and assuming the desired statistical power P = .8), gives

$$\square \geq \sqrt{\frac{2}{n}}\ (sd)\ (ta,v + t2(1\text{-}P),v)$$

$$k \;\square\; .20/(.8165)(5.54)$$

$$\square\; .044$$

Again, if the mean number of nests is 100, the CEMP Working Group Standard is met if counts vary no more than 4.4% from the mean (i.e. they are not less than 95.6 (rounded to 96) or higher than 104.4 (rounded to 104).

$$\Delta \geq (.8165, \text{ the square root of } 2/3) \left[\left(\frac{k - 1}{\sqrt{3}} \right) (y) \right] (5.54, \text{ the sum of } t_{\alpha,v} + t_{2(1-P),v})$$

If it is desired to detect a change of 20% of the smallest observation (Δ = .20y), then

$$.20y \geq 4.52 \left[\left(\frac{k - 1}{\sqrt{3}} \right) (y) \right],$$

$$.20y \geq 2.61 (k-1) (y), \text{ and}$$

$$k \leq 1.08$$

This would require investigators in applying the $\alpha = .01/P \geq .8$ CEMP Working Group mandate to insure that the largest count is no more than 108% of the smallest. So, in the example where the lowest nest count is 100, the highest count should not exceed 108.

In scenario (a), where a range of 95, 100, and 105 was examined, and the issue was keeping counts within a certain percentage of the mean, it was determined that a maximum count of 104 was necessary to satisfy the $\alpha = .01/P \geq .8$ mandate. In scenario (b), where a certain percentage above the lowest count is used as the measuring stick for satisfying the $\alpha = .01/P \geq .8$ mandate, 108% of the lowest count, 95, would yield a maximum count of 102.6 (or 103, rounded off).

As a practical matter, the second counting scenario appears much easier to use in the field. Instead of constantly recalculating means, investigators would be guided by a relatively simple calculation based on the lowest count, to insure that the requisite statistical power is attained. Thus it is recommended that for future work on the Inventory, the project's methodology be adjusted to reflect that

> . . . counts of adults, active nests, and chicks should be repeated until three counts are obtained, with the highest count being no more than 8% higher than the lowest count.